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WATERS OF THE RIO GRANDE AND ITS TRIBUTARIES.

LETTER

FROM

THE SECRETARY OF THE INTERIOR,

TRANSMITTING,

BY DIRECTION OF THE PRESIDENT, ORDERS AND REGULATIONS OF THE INTERIOR DEPARTMENT TOUCHING USE, APPROPRIATION, OR DISPOSITION FOR IRRIGATION OF THE WATERS OF THE RIO GRANDE AND ITS TRIBUTARIES IN COLORADO AND NEW MEXICO.

APRIL 29, 1911.—Referred to the Committee on Irrigation of Arid Lands and ordered to be printed.

U. S. DEPARTMENT OF THE INTERIOR,
Washington, April 27, 1911.

SIR: By direction of the President, and responsive to House resolution 944, Sixty-first Congress, third session, I have the honor to submit herewith copies of orders and regulations in the Interior Department and its bureaus touching the use, appropriation, or disposition for irrigation of the waters of the Rio Grande and its tributaries in Colorado and New Mexico, the Rio Grande reclamation project, together with a list of applications for rights of way, involving the waters of the Rio Grande and its tributaries, initiated or acted upon by this department since the passage of the reclamation act.

Very respectfully,

WALTER L. FISHER,
Secretary.

THE SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEPARTMENT OF THE INTERIOR,
UNITED STATES RECLAMATION SERVICE,
Washington, D. C., April 22, 1911.

THE SECRETARY OF THE INTERIOR.

SIR: In accordance with instructions of March 6, there are transmitted herewith certain data relating to the water of the Rio Grande. This material has been brought together in accordance with the reso-

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lution of the House of Representatives of March 2, 1911, which in substance directs that they be furnished, if not incompatible with public interests:

A. Copies of all Executive or department orders and regulations in the possession of the Interior Department and its bureaus touching upon the use, appropriation, application, or disposition for irrigation of the waters of the Rio Grande and its tributaries in Colorado and New Mexico.

B. The Engle reclamation project and lands to be reclaimed thereunder.

C. The negotiations with the Republic of Mexico concerning said waters.

D. Together with a list or statement of all private irrigation or reservoir projects initiated or attempted to be initiated from the waters of said river and its tributaries in Colorado and New Mexico, above said Engle project, or acted upon by said department since the passage of the reclamation act and the disposition of the same.

Upon the receipt of these instructions request was made that the bureaus concerned bring together the desired facts, and correspondence was also initiated with other departments in cases where the files of this department were incomplete on the subject. As a result of this investigation and correspondence, the accompanying papers included in Exhibits A, B, C, and D are presented.

Very respectfully,

F. H. NEWELL, *Director.*

EXHIBITS.

EXHIBIT A.—COPIES OF EXECUTIVE OR DEPARTMENT ORDERS, ETC.

The following copies have been furnished by the Commissioner of the General Land Office:

1. December 5, 1896, order of Secretary Francis.
2. December 18, 1896, reply of Commissioner Lamoreaux.
3. January 13, 1897, modification by Secretary Francis.
4. May 25, 1906, statement from Secretary Hitchcock transmitting complaint by Goudy.
5. July 10, 1906, instructions from Acting Secretary Ryan.
6. September 27, 1906. further instructions by Acting Secretary Ryan.
7. April 22, 1907, recommendations from Director Newell, approved by Secretary Garfield.
8. November 12, 1907, decision by Secretary Garfield.
9. November 21, 1907, approval of certain selections by Secretary Ballinger.

The above apparently includes copies of all executive or department orders and regulations touching the use, appropriation, application, or disposition for irrigation of the waters of the river, excepting those directly relating to the Engle Reservoir given below.

In this connection also is given correspondence with the Department of Agriculture with reference to certain data relating to the flow of the Rio Grande, which were apparently obtained during the years 1896 and 1897, and subsequent years, by the use of public funds, but which have never been available for use by the public in general or by State or Federal officials:

10. March 14, 1911, Secretary Fisher to Department of Agriculture.
11. March 18, 1911, Secretary Wilson to Department of the Interior.

DEPARTMENT OF THE INTERIOR,
Washington, December 5, 1896.

THE COMMISSIONER OF THE GENERAL LAND OFFICE.

SIR: Your office is hereby directed to suspend action on any and all applications for right of way through public lands for the purpose of irrigation by using the waters of the Rio Grande River or any of its tributaries in the State of Colorado or in the Territory of New Mexico until further instructed by this department.

Very respectfully, D. R. FRANCIS, *Secretary.*

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DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE.
Washington, D. C., December 18, 1896.

THE SECRETARY OF THE INTERIOR.

SIR: This office is in receipt of departmental order of December 5, 1896, directing the suspension of action "on any and all applications for right of way through public lands for the purpose of irrigation by using the waters of the Rio Grande River or any of its tributaries in the State of Colorado or in the Territory of New Mexico" until further instructions. In connection therewith I would call attention to the application of the Pecos Irrigation & Improvement Co., submitted to the department by this office on November 12, 1896; and those of the Mesilla Valley Land & Irrigation Co. and the Rio Grande Dam & Irrigation Co., submitted together August 15, 1896.

These applications are all that are pending before the department on recommendation of approval by this office and which come within the operation of said order.

Very respectfully, S. W. LAMOREUX, *Commissioner.*

DEPARTMENT OF THE INTERIOR.
Washington, January 13, 1897.

THE COMMISSIONER OF THE GENERAL LAND OFFICE.

SIR: By departmental letter of December 5, 1896, you were directed to suspend action on all applications for right of way for irrigation purposes by the use of the waters of the Rio Grande or any of its tributaries in Colorado or New Mexico till further instructed.

I now hereby modify the above order by limiting its application, so far as the tributaries of the Rio Grande are involved, to those tributaries which empty into that river above the point where it becomes the boundary between the United States and Mexico.

Very respectfully, D. R. FRANCIS, *Secretary.*

DEPARTMENT OF THE INTERIOR.
Washington, May 25, 1906.

THE COMMISSIONER OF THE GENERAL LAND OFFICE.

SIR: In a letter of January 25, 1906, to the department, Mr. F. C. Goudy, president of the Rio Grande Reservoir & Ditch Co., made complaint that the proposed construction of a reservoir by the company in Colorado for reclamation purposes and the procuring of a right of way therefor is being prevented by the Government.

In a report of February 26, 1906, on this letter the Director of the Geological Survey recommended that—

"If there be no objection on the part of the State Department, at whose instance the order of December 5, 1896, was made, the same be modified to permit the approval of rights of way for irrigation purposes on the tributaries of the Rio Grande which were initiated by actual field surveys based upon notices of appropriation of water filed under the laws of Colorado prior to March 1, 1903."

The Acting Secretary of State, in a letter of March 7, 1906, to the department, stated that—

"The Department of State approves the recommendation of the Director of the Geological Survey modifying the order of suspension in accordance with the request of the Rio Grande Reservoir & Ditch Co."

In a letter of the 22d instant to the department the Acting Secretary of State has extended the approval covered by the letter of March 7, supra—

"so as to include all companies or applicants whose rights of way for irrigation purposes on the tributaries of the Rio Grande * * * were initiated by actual field surveys based upon notices of appropriation of water filed under the laws of Colorado prior to March 1, 1903."

In view of the foregoing the departmental order of December 5, 1896, directing you to suspend action on all applications for right of way through the public lands for purposes of irrigation by using the waters of the Rio Grande or any of its tributaries in Colorado or New Mexico, and the order of January

13, 1897, modifying the original order so far as the tributaries of the Rio Grande are concerned by limiting its application to tributaries emptying into the Rio Grande above the point where it becomes the boundary between the United States and Mexico, are hereby modified so as to exclude from their operation all applications for right of way covered by the approval in the letter of the 22d instant from the Acting Secretary of State, quoted above.

The letter of Mr. Goudy is transmitted herewith.

Very respectfully,

E. A. HITCHCOCK, *Secretary.*

DEPARTMENT OF THE INTERIOR,
Washington, July 10, 1906.

The COMMISSIONER OF THE GENERAL LAND OFFICE.

SIR: In departmental letter of May 25, 1906, to you, departmental orders of December 5, 1896, and January 13, 1897, were modified so as to exclude from their operation all applications for rights of way through the public lands for purposes of irrigation by using the waters of the Rio Grande or any of its tributaries in Colorado and New Mexico initiated by actual field surveys based on notices of appropriation of water filed under the laws of Colorado prior to March 1, 1903, such modification being favored by the Acting Secretary of State in a letter of May 22, 1906, to the department.

In view of this modification of the orders mentioned you are directed that in acting on this class of applications, now on file or that may be filed hereafter in your office, to submit them to the Director of the Geological Survey to ascertain whether they will conflict with the obligations of the United States, under the treaty with Mexico, recently ratified, or with the Rio Grande or any other project of the Reclamation Service, and to transmit the reports of the director, with the applications when they are submitted for departmental action.

Very respectfully,

THOS. RYAN, *Acting Secretary.*

DEPARTMENT OF THE INTERIOR,
Washington, September 27, 1906.

The COMMISSIONER OF THE GENERAL LAND OFFICE.

SIR: In a letter of the 24th instant to the department the Acting Secretary of State has stated, with respect to applications for right of way through public lands for purposes of irrigation by using the waters of the Rio Grande or any of its tributaries in Colorado and New Mexico, that the Department of State perceives no reason for the further suspension of action on any application of such character.

He has stated further that the intent of the original departmental order of suspension dated December 5, 1896, was to conserve the interests of the Mexican Government in the waters of the Rio Grande pending an agreement between the United States and Mexico on the question, and that such an agreement has been reached and is embodied in the treaty signed May 21 last, by which the United States obligates itself to deliver to the Mexican Government 60,000 acre-feet of water annually.

He has accordingly recommended that the order of December 5, 1896, and all modifying orders be rescinded, thus removing, so far as the Department of State is concerned, all restrictions on the consideration of applications involving any enterprise of a character which, on investigation by the Reclamation Service, is found to be not prejudicial to the treaty interests of Mexico.

In view of this recommendation the departmental order of December 5, 1896, and the several modifying orders are hereby revoked, and it is hereby directed that before any applications involving the use of the waters mentioned in Colorado and New Mexico are submitted for final departmental action by you they be first submitted to the Director of the Geological Survey to ascertain whether favorable action thereon would interfere with any project of the Reclamation Service or with the obligations of the United States under the treaty of May 21, 1906, with Mexico.

Very respectfully,

THOS. RYAN, *Acting Secretary.*

DEPARTMENT OF THE INTERIOR,
UNITED STATES RECLAMATION SERVICE,
Washington, D. C., April 22, 1907.

The SECRETARY OF THE INTERIOR.

SIR: The situation on the Rio Grande requires careful consideration and determination of policy by the Secretary. Briefly stated, the conditions are these:

The United States has entered into a treaty with Mexico, proclaimed by the President on January 16, 1907, by which it is agreed that the United States shall deliver to Mexico 60,000 acre-feet of water at the head of the Mexican canal near El Paso. In order to carry out this part of the treaty Congress has appropriated, by act approved March 4, 1907, the sum of $1,000,000 toward the construction of a dam on the Rio Grande, this being assumed to furnish water for 25,000 acres at $40 per acre. The total estimated cost of this project, including the dam, will be $7,200,000, of which amount $200,000 has been set aside and is now being used in the construction of subsidiary works, notably a diversion dam above Las Cruces, N. Mex. The remaining amount, $6,000,000, must be obtained from the reclamation fund.

It is estimated that for this expenditure of $7,200,000 it will be possible to irrigate 180,000 acres at $40 per acre. Deducting the 25,000 acres in Mexico, this leaves 155,000 acres in New Mexico and Texas to refund the $6,200,000. By storing all the water of the Rio Grande, including storm floods, this acreage can be supplied. If the flow of the stream is notably diminished, the area to be served will be correspondingly reduced and the cost per acre increased. This increase of cost will probably be at the expense of the lands in the United States, as Congress has already made the appropriation for the building charge to comply with the terms of the treaty.

The headwaters of this river are in the State of Colorado, surrounding the San Luis Valley. For several years after December 5, 1896, the Department of the Interior refused to grant rights of way for reservoirs or canals on these headwaters because of the effect on the international problem below. The departmental order was first modified May 25, 1906, to permit approval in cases where the applicants made a showing of priority over the United States. After the Senate had advised the ratification of the treaty, on July 10, 1906, these orders of the department were revoked, and the Reclamation Service was required to pass upon each case as to conflict with the treaty of the Rio Grande project. Most of the older cases have been reported on favorably by the Reclamation Service. In some of the cases, especially the later ones, the conditions involved some doubt as to the advisability of approval, and the questions of policy to be considered by the department were reported to the General Land Office for submission to the department when the cases were presented for your consideration.

Recently a few exceptions have been made as to small reservoirs located high in the mountains, where it appeared that the construction of works would not interfere notably with the supply of water which could be had in the lower reservoir. In view of the fact, however, that the treaty above mentioned has been concluded and an appropriation has been made by Congress for constructing the works in part, it appears probable that any considerable extension of the reservoir system at the headwaters may interfere with the plans of the Government.

Wide publicity has been given to the fact that the department has in a few cases permitted the location of small reservoirs on the headwaters of the Rio Grande. As a result a considerable number of applications are being made for other reservoir sites. If it were practicable to lay down a general rule by which the smaller of these sites could be approved the results would probably be beneficial, but a practical difficulty arises in the possibility of defining the limits between the large and small projects. It is unquestionably true that if all of the large projects on the headwaters of the river which are planned by private parties could be actually constructed the water supply for the Government reservoir would be to a large extent cut off. It is important, therefore, to have a general rule which can be applied to all cases.

RECOMMENDATIONS.

I therefore recommend that the department lay down the general policy that until the development of irrigation on the upper Rio Grande, in the State of Colorado and the Territory of New Mexico, shall furnish sufficient data to determine the effect of the storage and diversion of water in that vicinity upon the

water supply for the Engle Reservoir of the Rio Grande project, no further rights of way be approved which involve the storage or diversion of the waters of the upper Rio Grande and its tributaries, except applications of two kinds: First, those in connection with which there is a showing that the rights of the parties were initiated prior to the beginning of active operations by the Reclamation Service for the Rio Grande project, namely, March 1, 1903; second, applications which involve the diversion or storage of not exceeding 1,000 acre-feet of water per annum.

When it becomes possible to determine the effect of the approved applications upon the water available for storage for the Rio Grande project, it may be possible to allow the use of rights of way to a greater extent than is now proposed.

Very respectfully,

F. H. NEWELL, *Director.*

Approved:

J. R. GARFIELD, *Secretary.*

APRIL 25, 1907.

DEPARTMENT OF THE INTERIOR,
UNITED STATES RECLAMATION SERVICE,
Washington, D. C., April 27, 1907.

THE COMMISSIONER OF THE GENERAL LAND OFFICE.

SIR: Inclosed herewith you will find copy of a letter dated April 22, 1907, addressed to the honorable the Secretary of the Interior, and approved by him under date of April 25, relative to the situation on the Rio Grande.

This is transmitted for your consideration in connection with applications for rights of way in that vicinity.

Very respectfully,

F. H. NEWELL, *Director.*

DEPARTMENT OF THE INTERIOR,
Washington, November 12, 1907.

THE COMMISSIONER OF THE GENERAL LAND OFFICE.

SIR: The department has again before it for consideration the application of A. V. Tabor for right of way, filed under the act of March 3, 1891 (26 Stat., 1095), on account of what is known as Rio Grande Reservoir, covering land in sec. 31, T. 41 N., R. 4 W., Del Norte land district Colorado.

This application was the subject of report by the Director of the Geological Survey under date of December 29, 1906, wherein it was said that—

"The matter was referred to the supervising engineer in charge of the operations of the Reclamation Service affecting the drainage of the Rio Grande, who reports that while the water of the reservoir applied for appropriating a part of the flood waters of the river would interfere with the Rio Grande project, the interference would be so slight as not to materially affect the project or the obligations of the United States under its treaty with Mexico. There is no objection, therefore, on the part of this office to the approval of the application."

In departmental decision of January 12 last, not reported, which was upon Tabor's appeal from your office decision of June 13, 1904, rejecting his application, this report from the Director of the Geological Survey was referred to, and, after disposing of other matters incidental to the application, the entire matter was returned without final action for the further consideration of your office in the light of the report of the Director of the Geological Survey and other matters disposed of in said departmental decision.

The application is again transmitted with your office letter of the 6th instant wherein attention is called to certain memorandum, prepared by the Reclamation Service, which received departmental approval April 25, 1907, which memorandum recommended the establishment of a general policy until the development of irrigation on the upper Rio Grande in the State of Colorado and the Territory of New Mexico shall furnish sufficient data to determine the effect of the storage and diversion of the waters in that vicinity upon the water supply of the Eagle Reservoir of the Rio Grande project, and that no further rights of way be approved which involve the storage or diversion of the upper Rio Grande and its tributaries, except applications of two kinds: First, those in connection with which there is a showing that the rights of the parties were initiated prior to the beginning of active operations by the Reclamation

Service for the Rio Grande project, namely, March 1, 1903; and, second, applications which involve the diversion or storage of not exceeding 1,000 acre-feet of water per annum, and therein you present the question as to whether said order of April 25, 1907, should be amended or whether Tabor's application should be approved upon the previous favorable report, notwithstanding said order.

In returning the papers it is but necessary to say that the policy defined in the memorandum which received departmental approval April 25, 1907, was not intended to affect applications upon which favorable reports had been previously made by the Reclamation Service, and that if Tabor's application is in all other respects satisfactory, as appears from your letter, it may be submitted for departmental approval.

Very respectfully, J. R. GARFIELD, *Secretary.*

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, D. C., November 21, 1907.

THE SECRETARY OF THE INTERIOR.

SIR: October 20, 1902, Albert R. Smith et al. filed in the district land office at Del Norte applications for right of way under the provisions of the act of March 3, 1891 (26 Stat., 1095), for the Elk Creek Reservoirs Nos. 1 and 2. These applications were returned by this office for certain corrections and the applicants were required to furnish certain additional data in order to complete their applications. July 27, 1905, the applicants filed new maps showing the reservoirs and furnished the additional data required. The land affected by the proposed right of way is within the Rio Grande drainage as well as within the San Juan National Forest. The Forest Service, Department of Agriculture, and the Reclamation Service were requested to report on these applications. November 13, 1905, the Reclamation Service reported that the allowance of these applications would interfere with the contemplated Rio Grande project to the extent of appropriating a part of the flood waters upon which the said project was dependent. In view of this report the applications were rejected by this office. From this action the applicants and their successors in interest—the Conejos County Reservoir Co.—appealed. Under date of August 25, 1906, the Acting Secretary of the Interior considered the case and stated that—

"In view of departmental order of May 25, 1906, modifying previous orders suspending all applications for right of way through the public lands for purposes of irrigation by use of the waters of the Rio Grande or any of its tributaries in Colorado or New Mexico and of the report of the Acting Director of the Geological Survey dated the 3d instant, the record is herewith returned for your further consideration without action upon the company's appeal at this time.

In his said report of August 3, 1906, the Acting Director of the Geological Survey stated that should the applicants show to the satisfaction of the department that their rights were initiated by actual field surveys based upon notice of appropriation of water filed under the laws of Colorado prior to March 1, 1903, his office would offer no objection at that time to the approval of the applicants if in conformity with the laws and regulations in other respects, in accordance with said departmental order of May 25, 1906. In view of departmental order of September 27, 1906, revoking the order of suspension of December 5, 1896, and the several modifying orders, and directing that all such applications for rights of way be submitted to the Director of the Geological Survey to ascertain whether favorable action thereon would interfere with any project of the Reclamation Service or with the treaty obligations of the United States with Mexico, the matter was again forwarded to the director with certificates of the State engineer of Colorado to the effect that the applicants on November 13, 1902, had filed in his office maps and statements of the said reservoirs in compliance with the laws of Colorado. In reply the Acting Director of the Geological Survey, under date of January 24, 1907, discussed the matter in detail, and concluded by stating that—

"The question whether the interference will be sufficient to justify the denial of the application is a matter of policy, to be determined by the Secretary of the Interior."

Subsequently, to wit, April 25, 1907, you approved the memorandum submitted to you by the Director of the Reclamation Service April 22, 1907, governing the applications for rights of way in the Rio Grande project. From

what has been stated heretofore the applications for right of way for the Elk Creek Reservoirs Nos. 1 and 2 come within the scope of the first exception noted therein, inasmuch as—

"The rights of the parties were initiated prior to the beginning of active operations by the Reclamation Service for the Rio Grande project, namely, March 1, 1903."

Meanwhile, the acting forester has reported that—

"It has been found that the maps were filed in the local land office prior to the date of the establishment of the San Juan National Forest, and for that reason no stipulations have been required."

In view of the premises, the applications having been examined and found to conform with the regulations, I recommend that the articles of incorporation and proofs of organization of the Conejos County Reservoir Co. be accepted for filing, and that the maps, herewith submitted, showing the reservoirs, be approved, subject to all valid existing rights.

Very respectfully,

R. A. BALLINGER,
Commissioner.

Approved, November 21, 1907.

FRANK PIERCE, *Acting Secretary.*

DEPARTMENT OF THE INTERIOR,
Washington, March 14, 1911.

The SECRETARY OF AGRICULTURE.

SIR: By resolution of the House of Representatives of March 2, 1911, the Secretary of the Interior was directed to furnish copies of all Executive or departmental orders and regulations touching upon the use, appropriation, application, or disposition for irrigation of the waters of the Rio Grande and its tributaries in Colorado and New Mexico, together with other data. In connection with the preparation of these and other related material it is important to have copies of certain original observations and measurements of the Rio Grande in San Luis Valley, Colo., made in 1896 and subsequent years, presumably in cooperation with and possibly under the direction of the Department of Agriculture.

It appears from the memoranda at hand that, beginning in 1896 or 1897, measurements of the flow of the Rio Grande and of the ditches taken from it were made during three or more consecutive years. These were carried on under the direction of Mr. L. G. Carpenter, of the State Agricultural College, Fort Collins, Colo., directly by Mr. J. D. Stannard, the salary and expenses of the latter being paid by the college from either State or Federal funds.

The records of these investigations were apparently made in books furnished by the agricultural college and purchased from Federal funds.

The measurements on the Rio Grande referred to were made of the flow of water in San Luis Valley, Colo., beginning above Del Norte and following the river, measuring the quantity diverted in canals and the quantity entering the river in defined channels. This investigation was carried on to the Colorado-New Mexico line.

In addition, measurements were made in a number of places of the flow of the river itself, which, taken in connection with the measurements of diversion and inflow, showed which, if any, stretches of the river were subject to gains or losses due to seepage.

During the first year of these studies a more elaborate investigation was undertaken than in the following years. A circuit of the entire valley was made and measurements had of all the streams entering from the mountains.

In addition, a study of the artesian-well district was made and an enumeration of the wells and measurement or estimate of the flow of these to show what amount of water was delivered to the surface of the land.

Reference has been made to these investigations and to the results attained, and there have been many efforts to obtain access to the original records for purposes of study and in connection with matters of public interest to the Federal Government and to the State. It is understood that the records have been retained by Mr. Carpenter personally, and that efforts made to obtain them by the State engineer of Colorado and by other persons have been unsuccessful. There appears to be no question but that these records were obtained and paid for in considerable part out of public funds and that they are withheld from use by the public or by public officials, and that efforts continued

through several years have failed to make these records available for public uses. They are now valuable in connection with questions as to water rights which will arise on the Rio Grande, especially in connection with the work undertaken by the Government in accordance with treaty with Mexico, and with various acts of Congress.

It is suggested that this matter of obtaining access to these notebooks or other records of essentially public property be taken up with the proper authorities of the Colorado Agricultural College, and that efforts be made to have these produced and deposited in the hands of a suitable public custodian, such as the State engineer of Colorado or some officer in Denver of the United States Geological Survey, where they may be available for examination or for copying by properly authorized agents of the Government.

Very respectfully,

WALTER L. FISHER, *Secretary.*

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., March 18, 1911.

THE SECRETARY OF THE INTERIOR.

SIR: I have received your letter of March 14, relative to securing access to certain observations and measurements of the Rio Grande made in 1896 and subsequent years, by Prof. L. G. Carpenter and his assistant, Mr. J. D. Stannard, of the Colorado Agricultural College.

In reply I beg to advise you that these measurements were made independently of any cooperation or direction of this department. Whether or not any of the funds received from the Federal Government by the Colorado Agricultural College and Experiment Station were employed in connection with the gathering of these data is not known to this department. The department's supervision over the funds given to the colleges and stations for investigation relates only to the proper use of these funds under the Federal statutes, and does not extend to a control of the results or the disposition made of them in any authoritative way.

I shall take pleasure in transmitting a copy of your communication to President Charles A. Lory, of the Colorado Agricultural College, and urging the desirability of making the data available to public use.

Very respectfully, your obedient servant.

JAMES WILSON, *Secretary.*

EXHIBIT B.—THE ENGLE RECLAMATION PROJECT AND LANDS TO BE RECLAIMED THEREUNDER.

The letter from the Commissioner of the General Land Office of March 14, 1911, and attached papers herewith transmitted, cover all executive orders and regulations governing applications for right of way involving the use of the waters of the Rio Grande and its tributaries referred to in the request above noted.

In addition, and as covering more directly the disposition for irrigation of the waters of the Rio Grande on the lands to be reclaimed by the Engle project, there is here given a copy of the articles of agreement of June 27, 1906, between the Secretary of the Interior and the two water users' associations representing the owners of the lands to be irrigated:

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, March 14, 1911.

THE SECRETARY OF THE INTERIOR.

SIR: Referring to your letter of the 6th instant, I have the honor to transmit herewith copies of the several orders governing applications for right of way involving the use of the waters of the Rio Grande and its tributaries, together with a list of such applications which were initiated or acted upon subsequent to the passage of the reclamation act, to wit, June 17, 1902.

Very respectfully,

S. V. PROUDFIT,
Assistant Commissioner.

ARTICLES OF AGREEMENT.

These articles of agreement, made and entered into this 27th day of June, 1906, by and between the United States of America, acting in this behalf by Jesse E. Wilson, Acting Secretary of the Interior, party of the first part, and the Elephant Butte Water Users' Association of New Mexico, a corporation duly organized and existing under the laws of the Territory of New Mexico, and the El Paso Valley Water Users' Association, a corporation duly organized and existing under the laws of the Territory of Arizona, parties of the second part, their successors and assigns:

Witnesseth, That whereas the Elephant Butte Water Users' Association of New Mexico is a corporation organized and existing under the laws of the Territory of New Mexico, and the El Paso Valley Water Users' Association is a corporation organized and existing under the laws of the Territory of Arizona, for the purposes mentioned in their articles of incorporation and by-laws, copies[1] of which are appended to this agreement, and are, for every purpose of the interpretation, construction, and consideration of this agreement and of the rights of the parties hereunder, to be deemed, held, read, and considered as if fully written out or printed herein and deemed a part hereof; and

Whereas the lands embraced within the area proposed to be irrigated, as described in said articles of incorporation or by-laws, are naturally desert and arid and incapable of proper cultivation without irrigation, and will to a greater or less extent remain unclaimed, unfit for habitation, and uncultivated, in which condition they, or a great part thereof, now are, unless the waters of the Rio Grande in New Mexico and its tributaries be impounded and the flow thereof otherwise regulated and controlled; and

Whereas the said Secretary of the Interior contemplates the construction of certain irrigation works under the provisions of an act of Congress entitled "An act appropriating the receipts from the sale and disposal of public lands in certain States and Territories to the construction of irrigation works for the reclamation of arid lands," approved June 17, 1902, for the irrigation and reclamation of the lands described in the said articles or by-laws; and

Whereas the incorporators and shareholders of said Elephant Butte Water Users' Association of New Mexico and El Paso Valley Water Users' Association are, and under the provisions of their articles of incorporation must be, owners and occupants of lands in said area, and in some cases are appropriators of water for the irrigation thereof, and in addition thereto such incorporators and shareholders and their successors or assigns must initiate rights to the use of water from the said proposed irrigation works to be constructed by the said Secretary of the Interior as soon as such rights may be initiated, and thereafter complete the acquisition thereof in the manner and upon the terms and conditions to be prescribed therefor by the Secretary of the Interior, which rights shall be, and thereafter continue to be, forever appurtenant to designated lands owned by such shareholders; and

Whereas neither the relative priority nor the extent of the individual appropriations of such water heretofore made by said incorporators and shareholders for the lands described in said articles or by-laws, and which are now vested rights, have been ascertained or determined, but said incorporators and shareholders have agreed among themselves, by the terms and provisions of said articles of incorporation and by-laws, upon the rules and principles by and upon which the relative priority and the extent of their several appropriations and vested rights to the use of such waters shall be determined:

Now, therefore, it is agreed and understood by and between the parties hereto:

1. That if the said Secretary of the Interior shall authorize and cause the construction of said irrigation works, the said associations will take prompt action to secure the determination by the courts of the relative rights of their shareholders to the use of water for said lands, and that in the determination of such rights and of their respective rights to the use of water acquired under said act of Congress, the rules and principles set out in said articles of incorporation and by-laws for such determination shall be deemed the established rules and principles for that purpose.

2. That only those who are or who may become members of said associations, under the provisions of their articles of incorporation and by-laws, shall be

[1] Not printed.

accepted as applicants for rights to the use of water available by means of said proposed irrigation works.

3. That the aggregate amount of such rights to be issued shall in no event exceed the number of acres of land capable of irrigation by the total amount of water available for the purpose, being (1) the amount now appropriated by the shareholders of said associations and (2) the amount to be delivered from all sources in excess of the water now appropriated; and that the Secretary of the Interior shall determine the number of acres so capable of such irrigation as aforesaid, his determination to be made upon due and expert consideration of all available data and to be based upon and measured and limited by the beneficial use of water.

4. That the payments for the water rights to be issued to the shareholders of said associations under the provisions of said act of Congress shall be divided into not less than 10 equal annual payments, the first of which shall be payable when the water is first delivered from said works, or within a reasonable time thereafter, and after due notice thereof by the Secretary of the Interior to the associations, and that the cost of said proposed irrigation works shall be apportioned equally per acre among those acquiring such rights:

Provided, That the charges apportioned under the integral part of the said irrigation works, known as the Leasburg Diversion Dam and Canal, the construction of which is now proposed, shall be paid in 10 equal annual installments, upon the terms herein specified:

Provided further, That in the assessment of the charges under the main Rio Grande project when constructed the Secretary of the Interior shall apportion equitably the charges therefor against the land irrigated under the Leasburg Diversion Dam and Canal, due allowance being made for the charges already paid under this agreement.

5. That the said water users associations hereby guarantee the payments for that part of the cost of the irrigation works which shall be apportioned by the Secretary of the Interior to their shareholders, and will promptly levy calls or assessments therefor and for the cost of maintenance and operation as may be assessed from year to year by the Secretary of the Interior, and collect or require prompt payment thereof in such manner as the Secretary of the Interior may direct; that they will promptly pay the sums collected by them to the receivers of the local land offices for the districts in which said lands are situated: that they will promptly employ the means provided and authorized by the said articles of incorporation and by-laws for the enforcement of such collections; and will not change, alter, or amend their articles of incorporation or by-laws in any manner whereby such means of collection, or the lien given to them by the shareholders to secure the payment thereof, or of any assessments contemplated or authorized thereby shall be impaired, diminished, or rendered less effective without the consent of the Secretary of the Interior.

6. That the United States shall in no manner be responsible for the sums collected by said associations until they have been paid into the hands of the receiver of the local land office, as provided by the law, and in accordance with such regulations as may be prescribed by the Secretary of the Interior.

7. That for the purpose of enforcing said collections the associations will adopt and enforce proper by-laws, subject to the approval of the Secretary of the Interior, and not change them so as to in anywise impair their efficiency for said purpose, and will otherwise do any and all things they are authorized and empowered to do in the premises.

8. That the associations will adopt and enforce such rules and regulations as they are authorized by their articles of incorporation and by-laws to adopt and enforce, concerning the use of water by their shareholders and concerning the administration of the affairs of the associations, to effectually carry out and promote the purposes of their organization, within the provisions of said articles of incorporation and by-laws, which rules and regulations shall be subject to the approval of the Secretary of the Interior, and that if the associations fail to make and adopt such rules and regulations, then the Secretary of the Interior may prescribe them; but in such event the Secretary of the Interior shall impose no rule or regulation interfering with any vested right of the shareholders of the associations, as defined or modified by said articles of incorporation and by-laws.

9. That persons who are not now members of the associations, but who may be the owners or occupants of land to be irrigated, as described in their

articles of incorporation or by-laws, or of added lands as therein provided for and to whom rights to the use of water from the proposed irrigation works may be issued by the United States, may, at the designation of the Secretary of the Interior, become members of the associations upon subscribing to the stock thereof and upon compliance with the other conditions prescribed for such membership.

10. That in all the relations between the United States and these associations and the members of the associations, the rights of the members of the associations to the use of water where the same have vested, are to be defined, determined and enjoyed in accordance with the provisions of the said act of Congress and of other acts of Congress on the subject of the acquisition and enjoyment of the rights to use water; and also by the laws of New Mexico and Texas, where not inconsistent therewith, modified, if modified at all, by the provisions of the articles of incorporation and by-laws of said associations.

11. That nothing contained in this agreement, or to be implied from the fact of its execution, shall be construed, held or deemed to be an approval by the Secretary of the Interior, nor an adoption by him of the articles of incorporation or by-laws of said associations in all their details as the form of organization of water users, contemplated and authorized by Section 6 of the said act of Congress of June 17, 1902; but such approval and adoption is expressly reserved until the conditions prescribed in said act authorizing such approval and adoption shall have arisen; and that when the Secretary of the Interior shall make, approve, and promulgate rules and regulations for the administration of the water to be supplied from said proposed irrigation works, such rules and regulations and such modifications thereof as the secretary may, from time to time, approve and promulgate, shall be deemed and held to be obligatory upon these associations as fully and completely, and to every intent and purpose as if they were now made, approved, promulgated, and written out in full in this agreement, and the same are to be so read and construed.

12. It is further understood and agreed that the charges apportioned by the Secretary of the Interior for the construction of the Leasburg Diversion Dam and Canal against the lands irrigated thereunder shall be upon the basis of the water available from the natural flow of the Rio Grande at said dam.

In witness whereof the undersigned have hereunto subscribed their names and affixed their seals the day and year first herein written.

[SEAL.] JESSE E. WILSON,
Acting Secretary of the Interior,
For and on behalf of the United States of America,
Party of the first part.

[SEAL.] ELEPHANT BUTTE WATER USERS' ASSOCIATION OF NEW MEXICO,
By H. B. HOLT, *President.*

Attest:
N. C. FRENGER, *Secretary.*

[SEAL.] EL PASO VALLEY WATER USERS' ASSOCIATION,
By A. COURCHESNE, *President.*

Attest:
F. MARTINE, *Secretary.*

EXHIBIT C.—NEGOTIATIONS WITH THE REPUBLIC OF MEXICO CONCERNING THE WATERS OF THE RIO GRANDE.

The negotiations with the Republic of Mexico have been conducted as a matter of course by the Department of State, and there do not appear to be on the files of the department copies of Executive or departmental orders relating to the matter. In order, however, to comply, as far as practicable, with this request, a letter was addressed to the Department of State on March 11, as given below:

DEPARTMENT OF THE INTERIOR,
Washington, March 11, 1911.

THE SECRETARY OF STATE.

SIR: By resolution of March 2, 1911, the House of Representatives directed that the Secretary of the Interior furnish certain facts concerning the Rio

Grande and its tributaries in Colorado and New Mexico, and in particular "the negotiations with the Republic of Mexico concerning said waters." The resolution is as follows:

"*Resolved*, That the Secretary of the Interior be, and he is hereby, directed to furnish to the House of Representatives, if not incompatible with the public interests, copies of all Executive or department orders and regulations in the possession of the Interior Department and its bureaus touching the use, appropriation, application, or disposition for irrigation of the waters of the Rio Grande and its tributaries in Colorado and New Mexico; the Engle reclamation project and lands to be reclaimed thereunder; the negotiations with the Republic of Mexico concerning said waters, together with a list or statement of all private irrigation or reservoir projects initiated or attempted to be initiated from the waters of said river and its tributaries in Colorado and New Mexico above said Engle project, or acted upon by said department since the passage of the reclamation act, and the disposition of the same."

It is inferred that the information desired is in connection with the discussion or correspondence which led up to the convention between the United States and Mexico providing for the equitable distribution of the waters of the Rio Grande for irrigation purposes signed at Washington May 21, 1906. It appears that the Department of State, as a result of certain international obligations, caused the institution of proceedings, through the Attorney General, May 24, 1897, to prevent the construction of irrigation works undertaken by the Rio Grande Dam & Irrigation Co. at what is known as the Elephant Butte, N. Mex.

Upon the filing of complaint by the Government of Mexico, the Secretary of the Interior on December 5, 1896, ordered the suspension of all applications for rights of way for irrigation ditches and reservoirs involving public lands on the Rio Grande, so as to prevent further diversions of water from this stream.

On June 27, 1904, the Hon. John Hay, then Secretary of State, suggested that a practical solution of the problems of water distribution on the Rio Grande might be accomplished under the terms of the reclamation act of June 17, 1902.

The above matters are cited as giving indication of the character or extent of the information which may be available, and it is requested, if not incompatible with the public interests, that this department be furnished with a statement of the negotiations with the Republic of Mexico or such other facts as may be relevant to the matter under consideration.

Very respectfully, R. A. BALLINGER, *Secretary.*

No reply has as yet been received to this request, but in order to furnish the material desired a brief statement is appended, including the material available concerning the negotiations which have apparently been an outgrowth of action by the Department of State in attempting to solve an international question involving claims presented by Mexico for losses to citizens of that Republic, due to the alleged interference with vested water rights. The State Department, as a result of public discussion of this matter, caused the institution of proceedings through the Attorney General May 24, 1897, to prevent the construction of irrigation works undertaken by the Rio Grande Dam & Irrigation Co. at what is known as the Elephant Butte, in New Mexico, on the Rio Grande, about 100 miles above El Paso. The projected works threatened to still further deprive Mexico of water which had been used for many years.

Upon request of the State Department, upon complaint of the Government of Mexico, the Secretary of the Interior on December 5, 1896, ordered the suspension of all applications for rights of way for irrigation ditches and reservoirs, involving public lands on the Rio Grande and its tributaries, so as to prevent further diversions of the waters of this stream. In a letter of June 27, 1904, from Hon. John Hay, Secretary of State, to Hon. Ethan Allen Hitchcock, Secretary of the Interior, the suggestion was made that a practical solution of the problems of water distribution on the Rio Grande might be accomplished under the terms of the reclamation act of June 17, 1902. He called attention to the proposition already made of establishing a reservoir near Elephant Butte. The matter was immediately taken up, and Mr. B. M. Hall, of the Reclamation Service, was placed in charge of further investigations, with the result that at the irrigation congress at El Paso, Tex., November 18, 1904, Mr. Hall presented a comprehensive scheme, which was agreed to by representatives of the people interested in New Mexico, Texas, and the Republic of Mexico.

On February 25, 1905 (33 Stat. L., 814). the reclamation act was extended to Texas, and on May 21, 1906 (34 Stat. L., 2593), a treaty with Mexico was signed in the following terms:

"*Convention between the United States and Mexico, providing for the Equitable Distribution of the Waters of the Rio Grande for Irrigation Purposes.*

"[Signed at Washington May 21, 1906; ratification advised by the Senate June 26, 1906; ratified by the President Dec. 26, 1906; ratified by Mexico Jan. 5, 1907; ratifications exchanged at Washington Jan. 16, 1907; proclaimed Jan. 16, 1907.]

"BY THE PRESIDENT OF THE UNITED STATES OF AMERICA.

"A PROCLAMATION.

"Whereas a convention between the United States of America and the United States of Mexico, providing for the equitable distribution of the waters of the Rio Grande for irrigation purposes, and to remove all causes of controversy between them in respect thereto, was concluded and signed by their respective plenipotentiaries at Washington on the 21st day of May, 1906, the original of which convention, being in the English and Spanish languages, is word for word as follows:

"The United States of America and the United States of Mexico being desirous to provide for the equitable distribution of the waters of the Rio Grande for irrigation purposes, and to remove all causes of controversy between them in respect thereto, and being moved by considerations of international comity, have resolved to conclude a convention for these purposes and have named as their plenipotentiaries:

"The President of the United States of America, Elihu Root, Secretary of State of the United States; and

"The President of the United States of Mexico, His Excellency Señor Don Joaquín D. Casasús, ambassador extraordinary and plenipotentiary of the United States of Mexico at Washington;

"Who, after having exhibited their respective full powers, which were found to be in good and due form, have agreed upon the following articles:

"ARTICLE I. After the completion of the proposed storage dam near Engle, N. Mex., and the distributing system auxiliary thereto, and as soon as water shall be available in said system for the purpose, the United States shall deliver to Mexico a total of 60,000 acre-feet of water annually, in the bed of the Rio Grande at the point where the head works of the Acequia Madre, known as the Old Mexican Canal, now exist above the city of Juarez, Mexico.

"ART. II. The delivery of the said amount of water shall be assured by the United States and shall be distributed through the year in the same proportions as the water supply proposed to be furnished from the said irrigation system to lands in the United States in the vicinity of El Paso, Tex., according to the following schedule, as nearly as may be possible:

	Acre-feet per month.	Corresponding cubic feet of water.
January	0	0
February	1,090	47,480,400
March	5,460	237,837,600
April	12,000	522,720,000
May	12,000	522,720,000
June	12,000	522,720,000
July	8,180	356,320,800
August	4,370	190,357,200
September	3,270	142,441,200
October	1,090	47,480,400
November	540	23,522,400
December	0	0
Total for the year	60,000	2,613,600,000

"In case, however, of extraordinary drought or serious accident to the irrigation system in the United States, the amount delivered to the Mexican Canal shall be diminished in the same proportion as the water delivered to lands under said irrigation system in the United States.

"ART. III. The said delivery shall be made without cost to Mexico, and the United States agrees to pay the whole cost of storing the said quantity of water to be delivered to Mexico, of conveying the same to the international line, of measuring the said water, and of delivering it in the river bed above the head of the Mexican Canal. It is understood that the United States assumes no obligation beyond the delivering of the water in the bed of the river above the head of the Mexican Canal.

"ART. IV. The delivery of water as herein provided is not to be construed as a recognition by the United States of any claim on the part of Mexico to the said waters; and it is agreed that in consideration of such delivery of water Mexico waives any and all claims to the waters of the Rio Grande for any purpose whatever between the head of the present Mexican Canal and Fort Quitman, Tex., and also declares fully settled and disposed of, and hereby waives, all claims heretofore asserted or existing, or that may hereafter arise, or be asserted, against the United States on account of any damages alleged to have been sustained by the owners of land in Mexico by reason of the diversion by citizens of the United States of waters of the Rio Grande.

"ART. V. The United States in entering into this treaty does not thereby concede, expressly or by implication, any legal basis for any claims heretofore asserted or which may be hereafter asserted by reason of any losses incurred by the owners of land in Mexico due or alleged to be due to the diversion of the waters of the Rio Grande within the United States; nor does the United States in any way concede the establishment of any general principle or precedent by the concluding of this treaty. The understanding of both parties is that the arrangement contemplated by this treaty extends only to the portion of the Rio Grande which forms the international boundary from the head of the Mexican Canal down to Fort Quitman, Tex., and in no other case.

"ART. VI. The present convention shall be ratified by both contracting parties in accordance with their constitutional procedure, and the ratifications shall be exchanged at Washington as soon as possible.

"In witness whereof the respective plenipotentiaries have signed the convention, both in the English and Spanish languages, and have thereunto affixed their seals.

"Done in duplicate at the city of Washington this 21st day of May, 1906.

"ELIHU ROOT. [SEAL.]
"JOAQUIN D. CASASUS." [SEAL.]

"And whereas the said convention has been duly ratified on both parts, and the ratifications of the two Governments were exchanged in the city of Washington on the 16th day of January, 1907:

"Now, therefore, be it known that I, Theodore Roosevelt, President of the United States of America, have caused the said convention to be made public, to the end that the same and every article and clause thereof may be observed and fulfilled with good faith by the United States and the citizens thereof.

"In testimony whereof I have hereunto set my hand and caused the seal of the United States of America to be affixed.

"Done at the city of Washington, this 16th day of January, in the year of our Lord 1907, and of the independence of the United States of America the one hundred and thirty-first.

"[SEAL.] THEODORE ROOSEVELT.

"By the President:

"ELIHU ROOT,

"Secretary of State."

The legislation supplementing the treaty with Mexico, intended to make the general plan effective, consists of the act of February 25, 1905, authorizing the construction of the dam; also the act of June 12, 1906, extending the reclamation act to Texas, and the act of March 4, 1907, providing $1,000,000 toward the expense of construction. These several acts are as follows:

"AN ACT Relating to the construction of a dam and reservoir on the Rio Grande, in New Mexico, for the impounding of the flood waters of said river for the purposes of irrigation.

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the provisions of the reclamation act approved June seventeenth, nineteen hundred and two, shall be extended for the purposes of this act to the portion of the State of Texas bordering upon the Rio Grande which can be irrigated from a dam to be constructed near

Engle, in the Territory of New Mexico, on the Rio Grande, to store the flood waters of that river, and if there shall be ascertained to be sufficient land in New Mexico and in Texas which can be supplied with the stored water at a cost which shall render the project feasible and return to the reclamation fund the cost of the enterprise, then the Secretary of the Interior may proceed with the work of constructing a dam on the Rio Grande as part of the general system of irrigation, should all other conditions as regards feasibility be found satisfactory. (33 Stat. L., 814.)

"Approved, February 25, 1905."

"AN ACT To extend the irrigation act to the State of Texas.

"*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That the provisions of the act entitled 'An act appropriating the receipts from the sale and disposal of public lands in certain States and Territories to the construction of irrigation works for the reclamation of arid lands,' approved June seventeenth, nineteen hundred and two, be, and the same are hereby, extended so as to include and apply to the State of Texas. (34 Stat. L., 259.)

"Approved, June 12, 1906."

A provision of the sundry civil appropriation act for the fiscal year ending June 30, 1908, reads as follows:

"Convention with Mexico: Toward the construction of a dam for storing and delivering sixty thousand acre-feet of water annually in the bed of the Rio Grande at the point where the headworks of the Acequia Madre now exist, above the city of Juarez, Mexico, as provided by a convention between the United States and Mexico, proclaimed January sixteenth, nineteen hundred and seven, one million dollars, to be available as needed and to be expended under the direction of the Secretary of the Interior in connection with the irrigation project on the Rio Grande: *Provided*, That the balance of the cost of said irrigation project over and above the amount herein appropriated shall be allotted by the Secretary of the Interior, as may be needed and as may be available from time to time, from the reclamation fund and collected from the settlers and owners of the land benefited under the provisions of the reclamation act approved June seventeenth, nineteen hundred and two, and acts supplemental thereto or amendatory thereof. (34 Stat. L., 1357.)

"Approved March 4, 1907."

In the meantime, while this legislation was under discussion, surveys and examinations were being conducted, resulting in report to the Secretary of the Interior by which the department decided that there was a feasible project within the terms of the reclamation act, and one which would provide a satisfactory supply for lands in Mexico, as well as those in the United States. In the Third Annual Report of the Reclamation Service (pp. 396–426), submitted to Congress in December, 1904, is published a full statement of the proposed plans for the Rio Grande project, including a discussion of the Engle Reservoir, Engle Dam, and Leasburg diversion. To the end of that fiscal year there had been expended from the reclamation fund for the Rio Grande project about $37,000 for surveys and preliminary examinations.

In the following year surveys were made for the Leasburg diversion, and the water users in the entire project were organized. (Fourth Annual Report Reclamation Service, pp. 279–280.) During that fiscal year, there was expended for the project from the reclamation fund, $5,843.44. The act of February 25, 1905 (34 Stat., 814), authorized such operations in Texas as might be required in connection with this project.

The project was formally adopted by the Secretary of the Interior on December 2, 1905, and an allotment of $200,000 was made therefor from the reclamation fund. During the fiscal year ending June 30, 1906, preliminary work on the Leasburg diversion dam was performed and the expenditures amounted to $12,394.19. (Fifth Annual Report, pp. 200–224.)

In the next year, 1907, the treaty with Mexico was proclaimed, this being on January 16, 1907, and the appropriation of $1,000,000 was made March 4, 1907, not becoming available, however, until after the end of that fiscal year. During this fiscal year and pending the special appropriation work was carried on in connection with the Engle Reservoir site in the examination of land-office and court records, with a view to the acquisition of title to lands in the reservoir site. Active field work was prosecuted on the Leasburg diversion dam and canal, and the total expenditures on the entire project were $83,250.06, all charged against the reclamation fund.

It will be noted that up to this time there had been expended on the project $138,487.69, drawn entirely from the reclamation fund. Of this amount $48,730.30 had been expended upon the Engle Reservoir.

The Leasburg diversion dam and canal is an important portion of the entire project, because this diversion dam and canal forms a part of the plan for handling the stored water from the Engle Reservoir to the head of the Mexican canal near El Paso to be delivered to Mexico under the treaty.

During the fiscal year ending June 30, 1908, active operations were in progress to complete the topographic and land-ownership survey of the Engle Reservoir site. Surveys and negotiations were also made for a branch railroad from a point near Engle to the dam site and also for wagon roads and trails, and contract finally formulated to provide for construction. The walls of the dam site were thoroughly prospected, and plans for various preliminary operations were prepared. The Leasburg diversion dam and canal were completed and placed in operation for the irrigation of about 15,000 acres. During this fiscal year there was expended on the project $128.356.79, of which $27,380.02 were expended on the Engle Dam and Reservoir, about $4,000 being expended from the reclamation fund and $23,313.13 from the Rio Grande Dam appropriation. (Seventh annual report, Reclamation Service, pp. 149–152.)

In the fiscal year ending June 30, 1909, the topographic survey of the storage-reservoir site was completed, a large amount of development work was done in the vicinity of the dam site, a water-supply system provided, and a reenforced-concrete water tank was erected; the railroad line was finally located, partly graded, and active work was in progress for the preliminary operations at the dam site, when the work was stopped in May, 1909, by orders of the company owning the land, after it became evident that a satisfactory agreement for purchase could not be reached. Thereupon steps were promptly taken to acquire the land by condemnation proceedings.

The Leasburg Dam and Canal were operated during the year for the irrigation of the lands under it. The total expenditures for the year upon the project were $114,502.95, of which $103,441.66 were expended upon the Engle Dam and Reservoir. (Eighth annual report, pp. 140–145.)

The special fund for the Rio Grande Dam became available July 1, 1907. Thereupon, as shown above, the surveys and investigations previously begun were actively continued, and negotiations were undertaken to acquire the lands needed for the reservoir site, somewhat more than 40,000 acres. Of this, more than 30.000 acres belong to the Victorio Land & Cattle Co. The negotiations were carried on until May, 1909, when it was found impracticable to reach a decision, and the company demanded that all work upon its property cease at once. During this period of 1 year and 10 months much preliminary work has been done, including all that was practicable prior to securing the ownership of the land.

Aside from the large tract of land owned by the corporation referred to, there are a large number of small holdings, about 200 in number. Negotiations have been constantly in progress, and a number of the tracts have been contracted for or acquired. The surveys of these lands to ascertain the boundaries on the ground and negotiations with the owners, practically all of whom are Mexicans, has been very difficult, but has been vigorously carried forward.

The special appropriation for the dam site has up to this date been available for active construction and field operations on the dam only during the time that the owner of the dam site did not object to work, a period of less than two years, and up to the date of April 30, 1910, $447,026.83 has been expended for the Rio Grande project as a whole. $260,801.53 having been expended from the reclamatoin fund. On the Engle Dam and reservoir a total of $252,535.12 has been expended, of which $67,276.57 has been spent from the reclamation fund and $185,258.55 from the special appropriation for the Engle Dam.

Owing to the failure to arrive at an amicable settlement, the further work of preparation for the construction of the dam was stopped by order of June 19, 1909, from H. A. Jastro, general manager of the Victorio Land & Cattle Co. Proceedings were at once begun in the court of New Mexico, and in May, 1910, an award was made of approximately $200,000. The matter was discussed, and it was concluded that, although the award appeared to be excessive, it was the consensus of opinion of those interested that it would be better to pay a somewhat larger amount and proceed with the construction than to delay further.

By letter of May 23, 1910, the Secretary of the Interior states:

"If the Engle Dam proposition were one in which only the citizens of this country were interested, I would not feel justified at this time in taking any action looking to its construction from moneys in the reclamation fund if by so doing the completion of other projects would thereby be delayed. But said dam occupies a different status than the other approved projects, in that it is one in which the citizens of the Republic of Mexico are interested, and the faith of this Government is pledged by solemn treaty to begin and complete it at as early a date as possible. To carry out the provisions of the treaty, Congress by act of March 4, 1907 (34 Stat. L., 1357), made a direct appropriation of $1,000,000, and at the same time provided 'that the balance of the cost of said irrigation project' be paid 'from the reclamation fund.' In view, therefore, of our treaty obligations with the Republic of Mexico and of the said act of Congress, I feel that it is incumbent upon this department to construct said dam as soon as possible, even though the completion of other projects be delayed thereby. I therefore direct you to advise the engineers 'to so plan the work as to be ready to begin upon the foundations in July, 1911.'"

EXHIBIT D.—LIST OF PRIVATE PROJECTS ACTED UPON BY THE DEPARTMENT.

The resolution of March 2 calls for a list or statement of all private irrigation or reservoir projects initiated, or attempted to be initiated, from the waters of the Rio Grande and its tributaries in Colorado and New Mexico above the Engle project, acted upon by the department since the passage of the reclamation act, and the disposition of these. Such list has been obtained from the Commissioner of the General Land Office and is as follows:

List of applications involving waters of Rio Grande drainage, initiated or acted upon since passage of reclamation act, to wit, June 17, 1902.

	Location.	Remarks.
Toltec Canal Co.:		
Taos Valley Canal	T. 33 N., Rs. 9, 10 E.	Act Mar. 3, 1891 (26 Stat., 1095); approved Feb. 18, 1909.
Cove Lake Reservoir	Tps. 32, 33 N., R. 10 E.	
Alta Lake Reservoir	T. 32 N., R. 9 E.	
Taos Valley Canal No. 2	Tps. 32, 33 N., Rs. 9, 10 E.	
Taos Valley Lateral No. 1	T. 32 N., Rs. 9, 10 E.	
E. J., J. H., and C. S. Shaw, and E. Stout, reservoir.	Sec. 6, T. 38 N., R. 2 E. Sec. 31, T. 39 N., R. 2 E.	Approved Oct. 26, 1907; act Mar. 3, 1891.
Ute Lake Reservoir	Sec. 14, T. 39 N., R. 5 W New Mexico principal meridian.	Accepted for filing Sept. 25, 1907; act Mar. 3, 1891.
G. T. Robb	Unsurveyed	
L. Regan, reservoir	Sec. 31, T. 41 N., R. 3 W. Sec. 36, T. 41 N., R. 4 W.	Suspended; act Mar. 3, 1891.
Rio Grande Reservoir & Ditch Co.:		
Reservoir	T. 41 N., R. 2 W.	Approved Nov. 16, 1907; act Mar. 3, 1891.
Ditch	T. 41 N., Rs. 2, 3 W.	
Continental Land & Irrigation Co., reservoir	T. 42 N., R. 3 W.	Approved Apr. 22, 1908; act Mar. 3, 1891.
San Luis Valley Reservoir Co., reservoir	T. 39 N., R. 3 E.	Approved June 2, 1908; act Mar. 3, 1891.
Conejos County Valley Reservoir Co.:		
Elk Creek Reservoir No. 1	T. 33 N., R. 5 E.	Approved Nov. 22, 1907; act Mar. 3, 1891.
Elk Creek Reservoir No. 2	T. 34 N., Rs. 4, 5 E.	
Union Reservoir & Ditch, Albert L. Smith et al.:		
Reservoir	Tps. 33, 34 N., R. 8 E.	Approved Dec. 13, 1906; act Mar. 3, 1891.
Ditch and tunnel	T. 33 N., Rs. 7, 8 E.	
Bennett Creek Park Reservoir, Thos. A. Good, reservoir.	T. 37 N., R. 5 E.	Approved Sept. 11, 1907; act Mar. 3, 1891.
Rio Grande Reservoir, A. V. Tabor	Tps. 40, 41 N., R. 4 W.	Approved Nov. 19, 1907; act Mar. 3, 1891.
North Clear Creek Reservoir, F. W. Bosco and C. Miller.	T. 41 N., R. 3 W. T. 42 N., R. 3 W.	Act Mar. 3, 1891; rejected.
J. Davies, reservoir	T. 43 N., R. 2 W.	Approved Apr. 12, 1910; act Mar. 3, 1891.
Grace Reservoir site: A. F. Fulington and M. A. Grace.	T. 41 N., R. 4 W.	Approved Mar. 25, 1907; act Mar. 3, 1891.
Hot Springs Reservoirs 1 and 2, Wm. J. Palmer	T. 39 N., R. 1 W.	Approved Oct. 28, 1908, and Nov. 9, 1908; act Mar. 3, 1891.
Conejos Reservoir, A. Jacob	T. 33 N. T. 34 N., R. 5 E.	Act Mar. 3, 1891; rejected.
Elk Creek Reservoir, C. A. Galbreath	T. 40 N., R. 2 E. T. 40 N., R. 3 E.	Approved Dec. 5, 1910; act Mar. 3, 1891.
C. Keck, reservoir	T. 38 N., R. 3 E.	Approved Apr. 16, 1908; act Mar. 3, 1891.

List of applications involving waters of Rio Grande drainage, etc.—Continued.

	Location.	Remarks.
J. H. Poage, reservoir	T. 38 N., R. 3 E.	Approved Feb. 18, 1907; act Mar. 3, 1891.
Red River Land & Water Co., canals	T. 28 S. T. 29 S. T. 30 S. T. 3 N., Rs. 12 and 13 E.	Approved Sept. 9, 1908; act Mar. 3, 1891.
San Luis Valley Irrigation Land & Power Co., reservoir.	T. 36 N., R. 6 E.	Approved June 1, 1908; act Mar. 3, 1891.
C. G. Emery, reservoir, ditch, and pipe line	Unsurveyed	Permission granted Oct. 28, 1907; act Feb. 15, 1901.
Yerno Development Co., ditches	From sec. 14, T. 28 S., R. 73 W., sixth principal meridian, to sec. 28, T. 37 N., R. 12 E., New Mexico principal meridian.	Abandoned.
South Fork Reservoir Co., reservoir	T. 39 N., R. 2 E.	Act Mar. 3, 1891; rejected.
Atlantic ditches	Tps. 39, 40 N., R. 4 E.	Pending; act Mar. 3, 1891.
Gabino Gallegos et al., ditch	T. 35 N., R. 8 E.	Rejected; act Mar. 3, 1891.
Stanley Land & Irrigation Co., reservoir	T. 11 N., R. 10 E.	Act Mar. 3, 1891; rejected.
American Power lines	T. 40 N., Rs. 4 and 5 W.	Act Feb. 15, 1901; rejected.
Show Creek Reservoir	T. 39 N., R. 4 E.	Pending; act Mar. 3, 1891.

Right of way—Reservoir site—Jurisdiction of Land Department.

Francis W. Bosco et al.

Whether the United States has a prior, superior and paramount claim to waters of the Rio Grande to the extent necessary to enable it to keep its treaty obligations with the Republic of Mexico with reference to the delivery of such waters is a question not within the competency of the Land Department to determine, and the Secretary of the Interior will not embarrass the decision of such question, nor the fulfillment of the Nation's obligations under such treaty, by approving applications for rights of way under the act of March 3, 1891, which rest upon the appropriation of such waters under State laws and their proposed diversion to other and adverse uses.

The extent of the grant made by the act of March 3, 1891, is defined by the statute, and the Secretary of the Interior is not authorized to accord a qualified approval of applications filed thereunder for the purpose of limiting the estate thereby granted.

First Assistant Secretary Pierce to the Commissioner of the General Land Office, July 19, 1910.
(F. W. C.) (G. B. G.)

This is the appeal of Francis W. Bosco and Cyrus Miller from your office decision of November 5, 1909, rejecting their joint application of July 8, 1909, under sections 18 to 21, inclusive, of the act of March 3, 1891 (26 Stat., 1101), and section 2 of the act of May 11, 1898 (30 Stat., 404), for right of way for the Wagon Wheel Gap Reservoir, involving certain lands in Mineral County, Del Norte land district, Colorado.

The decision appealed from rests wholly upon a report of the Director of the Reclamation Service October 19, 1909, which stated that "The approval of said application would constitute a serious interference with the Rio Grande project now under consideration," and recommended that the application be rejected. The merits of the case were not discussed in said decision, and it may be here stated that your office raises no question as to the technical sufficiency of the application, and no such question has been mooted before the department.

The applicants were accorded, and had, an oral hearing, and the case was most elaborately argued and has been most carefully considered, more especially as it involves some important and far-reaching questions. As preliminary to a consideration of these questions, it should be stated that the application of Bosco and Miller is predicated upon alleged prior appropriation of waters of the upper Rio Grande, in the State of Colorado, sufficient to supply the proposed reservoir, which will hold, when completed, according to the survey thereof, 994,000 acre-feet of water, and this survey covers certain public lands of the United States upon which the applicants must secure a right of way under Federal laws. They seek to do this by the filing of maps under the provisions of the act of March 3, 1891, supra, for the approval of the Secretary of the Interior. The objection to such approval rests upon certain important and vital interests of the United States in the waters of the Rio Grande, in connection with its irrigation project in New Mexico, known as the Engle Dam project,

and the proposed storage of waters therein to the keeping of certain treaty obligations to the Republic of Mexico.

A controversy some time arose between the United States and the Republic of Mexico relative to use of the waters of the Rio Grande, and was existent on December 5, 1896, when, because of such controversy, the then Secretary of the Interior promulgated the following order, addressed to the Commissioner of the General Land Office:

"Your office is hereby directed to suspend action on any and all applications for right of way through public lands for the purpose of irrigation by using the waters of the Rio Grande River, or any of its tributaries, in the State of Colorado or in the Territory of New Mexico, until further instructed by this department."

There were subsequent modifications of this order, but for the purposes of this case they are unimportant, except the last order on the subject, April 25, 1907, to which attention will be hereinafter given.

May 21, 1906, there was signed at Washington a convention between these sovereignties, article 1 of which is as follows:

"After the completion of the proposed storage dam near Engle, N. Mex., and the distributing system auxiliary thereto, and as soon as water shall be available in said system for the purpose, the United States shall deliver to Mexico a total of 60,000 acre-feet of water annually, in the bed of the Rio Grande at the point where the head works form Acequia Madre, known as the Old Mexican Canal, now existing above the city of Juarez, Mexico."

This convention was duly ratified by the contracting parties, and was proclaimed by the President of the United States January 16, 1907 (34 Stat., 2953). To carry out this treaty stipulation "in connection with the irrigation project on the Rio Grande," Congress, by the act of June 4, 1907 (34 Stat., 1357), appropriated the sum of $1,000,000 toward the construction of a dam on said river, and it appears from a report by the Director of the Geological Survey, April 27, 1910, that about $500,000 has been expended in connection with the Engle Dam. The total estimated cost of the project, including the dam, is $7,000,000 to $8,000,000. It further appears from said report that on June 27, 1906, the Secretary of the Interior entered into a contract with the Elephant-Butte Water Users' Association and the El Paso Water Users' Association providing for the construction of the Engle Dam project by the United States, and the repayment of the cost of such construction by these associations. In this status of the matter, on April 25, 1907, the then Secretary of the Interior approved a recommendation by the Director of the Reclamation Service as follows:

"I therefore recommend that the department lay down the general policy that until the development of irrigation on the upper Rio Grande in the State of Colorado and the Territory of New Mexico shall furnish sufficient data to determine the effect of the storage and diversion of water in that vicinity upon the water supply for the Engle Reservoir of the Rio Grande project, no further rights of way be approved which involve the storage or diversion of waters of the upper Rio Grande and its tributaries, except applications of two kinds: First, those in connection with which there is a showing that the rights of parties were initiated prior to the beginning of active operations by the Reclamation Service for the Rio Grande project, namely, March 1, 1903; second, applications which involve the diversion or storage of not exceeding 1,000 acre-feet of water per annum. When it becomes possible to determine the effect of the approved applications upon the water available for storage from the Rio Grande project, it may be possible to allow the use of rights of way to a greater extent than is now supposed."

Manifestly, if this order was within the competency of the Secretary of the Interior to make, and is to stand, it results that the pending application of Bosco and Miller must be rejected. The application does not come within either of the exceptions named in said order, and may not be allowed except in violation thereof. After a most painstaking consideration of the entire subject with reference to the situation presented, the department can not see its way clear to approve this application. It may, for the purpose of this case, be admitted that under ordinary circumstances the Secretary of the Interior is without discretion to withhold his approval of an application filed conformably to the act of March 3, 1891. But manifestly, here is a situation unusual and critical, which demands the exercise of such discretion. The paramount rights and interests of the United States are vitally involved in this proceeding. No question of the authority of the United States can well be urged in this proceeding. The power to make treaties with foreign nations has been delegated by the States to the Nation, and is exclusive; and it is well settled that where such a power has been

delegated the grant carries with it all subsidiary powers necessary to its exercise:

"'Let the end be legitimate, let it be within the scope of the Constitution, and all means which are appropriate, which are plainly adapted to that end, which are not prohibited, but consist with the letter and spirit of the Constitution, are constitutional.' * * * From this and other declarations it is clear that the Constitution is not to be construed technically and narrowly, as an indictment, or even as a grant presumably against the interest of the grantor, and passing only that which is clearly included within its language, but as creating a system of government whose provisions are designed to make effective and operative all the governmental powers granted." (Kansas *v.* Colorado, 206 U. S., 46, 88.)

Moreover, the question is one not within the competency of the Land Department to determine, and this is sufficient reason to justify that department in refusing to take any action which might in any way embarrass the United States in fulfilling its treaty obligations, or further complicate a question it is without right or jurisdiction to decide. It is not overlooked that the contention is made upon this record, and was presented at length at the oral hearing, that the diversion of water necessary to carry the Wagon Wheel Gap project to completion will in nowise interfere with the storage of the necessary waters by the United States Engle Dam, to enable it to keep both its treaty obligations with the Republic of Mexico and its contractual obligations with the water users associations above referred to. The department is by no means convinced that this is true, and in the absence of such conviction it is believed to be the duty of the Secretary of the Interior to exercise such discretion as is necessary to protect the interests of the United States.

At the oral hearing it was suggested on behalf of the Secretary of the Interior that, in the event of a determination of the legality of the suggestion, if the applicants would accept an approval qualified by such language as would protect the interest of the United States in the Engle Dam project, such qualified approval might be accorded. Counsel for the applicants were not at that time able to answer as to whether the applicants would be willing to accept such qualified approval, and since that time the Secretary of the Interior has caused to be examined the law with reference to this question, and in an opinion by the Assistant Attorney General for this department, June 14, 1910, referring to the essentially similar act of March 3, 1875, granting rights of way through the public lands of the United States to railroad companies in a case where it was sought to impose a limitation upon the approval of the Secretary provided for by that act, it was said:

"The statute defined the extent of the grant, and in my opinion, upon compliance with the requirements of the law, the Secretary of the Interior is without power either to expand or limit the same; the restriction being unlawful can accomplish nothing and is unenforceable."

In the present case, the question is resolved into whether the aforesaid order of April 25, 1907, reserving public lands on the waters of the Rio Grande from appropriation under the act of March 3, 1891, will be permitted to stand. As to the legality of such withdrawals there would seem to be no doubt; at any rate, for reasons already stated, this department is not disposed to question their legality. If a serious question might have been made as to their legality in connection with the irrigation project of the United States in New Mexico standing alone, still it seems plain that if the withdrawal of these lands was necessary to enable the United States to keep its treaty obligation with the Republic of Mexico (a fact which has already been determined), there would seem to be little room for question that the withdrawals were legally justifiable upon that ground alone. However this may be, the executive arm of the Government has determined to uphold this policy to the extent of its power, and these questions may well be left to the courts, where they may ultimately go. There are involved in this case certain other kindred questions, among which is that of priority of appropriation of waters, the legality of appropriations by the United States, and lack of diligence in appropriation to a beneficial use. It might be argued with considerable force that the aforesaid treaty with Mexico in itself amounted to an appropriation of these waters to the extent of 600,000 acre-feet—an appropriation by the highest authority. But these questions also must finally be resolved by the courts. In the meantime the Government proposes to push the Engle Dam project to completion with all possible dispatch; and to the end that it may be successfully operated and maintained, the withdrawal of April 25, 1907, will not be disturbed.

The decision appealed from is affirmed.

[Reprint from House Doc. No. 1262, Sixty-first Congress, third session.]

FUND FOR RECLAMATION OF ARID LANDS.

MESSAGE FROM THE PRESIDENT OF THE UNITED STATES, TRANSMITTING A REPORT OF THE BOARD OF ARMY ENGINEERS IN RELATION TO THE RECLAMATION FUND.

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FUND FOR RECLAMATION OF ARID LANDS.

MESSAGE OF THE PRESIDENT.

To the Senate and House of Representatives:

The act of Congress approved June 17, 1902 (32 Stats., 388), set apart as a fund for the reclamation of arid lands the moneys received from the sales of public lands in certain of the States and Territories, excepting the 5 per cent of the proceeds of such sales theretofore set aside by law for educational and other purposes. The receipts into the reclamation fund to June 30, 1909, were $58,439,408.93, and the estimated total receipts to June 30, 1910, are $65,714,179.06. The total amount accumulated in the fund to date is estimated at $69,449,058.76, of which all but $6,241,058.76 has been allotted to the several projects. On June 30, 1910, the net investment in reclamation works amounted to $53,781,302.88, of which $52,945,441.03 had on June 30, 1910, been expended in the following primary projects:

States.	Project.	Net investment.
Arizona	Salt River	$8,430,959.16
Arizona-California	Colorado River	44,201.97
California	Orland	378,603.11
Arizona-California	Yuma	3,781,355.19
Colorado	Grand Valley	73,110.38
Do	Uncompahgre	4,166,639.04
Idaho	Boise	3,373,292.30
Do	Minidoka	2,900,896.56
Do	Snake River storage	69,142.75
Kansas	Garden City	378,316.07
Montana	Huntley	854,420.36
Do	Milk River	519,387.23
Do	St. Mary	265,874.03
Do	Sun River	599,958.59
Montana-North Dakota	Lower Yellowstone	2,888,899.93
Nebraska-Wyoming	North Platte	4,609,476.50
Nevada	Truckee-Carson	3,975,976.42
New Mexico	Carlsbad	617,665.56
Do	Hondo	346,024.76
Do	Leasburg	193,418.82
New Mexico-Texas	Rio Grande	76,060.58
North Dakota	Buford-Trenton	278,294.40
Do	Williston	528,171.31
Oklahoma	Cimarron	8,873.17
Oregon	Central Oregon	40,133.44
Do	Umatilla	1,155,983.22
Oregon-California	Klamath	1,830,600.39
South Dakota	Bellefourche	2,313,525.22
Utah	Strawberry Valley	913,177.91
Washington	Okanogan	538,281.41
Do	Yakima	3,116,333.48
Wyoming	Shoshone	3,378,387.87
Total		52,945,441.03

In addition, there had been invested in secondary projects June 30, 1910, $587,390.71; in town-site development, $10,955.49; in Indian irrigation, $198,704.21; and for general expenses, $38,811.44.

The reclamation act requires the return to the reclamation fund of the estimated cost of construction, and therefore entrymen and private landowners receiving water from such projects are required to contribute their proportion of the cost of construction, operation, and maintenance of the projects wherein their lands are located. The total cash returns to the reclamation fund from water right building charges to June 30, 1910, were $902,822.25, and from water right operation and maintenance charges, $249,637.19. In addition, there was to June 30, 1910, an additional revenue of $2,086,173.73 derived from sales of town lots, sales of water, leases of power, etc., which are under the law credited as a reduction of the cost of the project from which the receipts are derived. On June 30, 1910, the Government was prepared to supply water in reclamation projects to 876,684 acres of land, and the area of lands included in the projects now under construction amounts to over 3,100,000 acres. No new projects have been undertaken since March 4, 1909, the efforts of the Government having been directed toward the completion of the 30 primary projects theretofore undertaken.

The additions to the reclamation fund from the sales of public land, while approximating between six and seven million dollars per annum since 1902, were found to be insufficient for the completion of existing projects with such expedition as the necessities of the settlers and land owners within the projects undertaken seemed to require. I accordingly recommended the issuance of certificates of indebtedness or bonds against the reclamation fund. The act of June 25, 1910 (36 Stats., 835), which authorized the issuance of not exceeding $20,000,000 of certificates of indebtedness repayable out of the reclamation fund, made the appropriation subject to the conditions that it should be expended upon existing projects and their necessary extensions, and that no part of the same should be expended until after the projects had been examined and reported upon by a board of Army engineer officers of the United States Army and approved by me as feasible, practicable, and worthy. The board of engineers selected spent the summer in field examinations of the projects and has submitted to me its report upon each of the projects heretofore undertaken, together with recommendations as to the allotment of the proceeds of the certificates authorized to be issued. In addition, pursuant to my request, the board has submitted its recommendations for the allotment of that part of the reclamation fund derived from the sales of public lands to supplement the $20,000,000 loan and to carry on worthy projects not participating in the distribution of the loan.

The report of the board is based not only upon its field examination of the various projects but upon information derived from personal conference with the field officers and employees of the Reclamation Service and data furnished by such officers and employees. In addition, settlers, landowners, and other parties interested in the projects were given an opportunity to be heard. The feasibility of the projects was considered from an engineering and economic standpoint, the board giving consideration to the character of the projects, whether international, interstate, or intrastate, the relative amounts of public and private lands capable of irrigation, the money already expended, the necessity of completion of the projects in order to secure its return, the existing contracts or agreements with water users' associations and private individuals, and the protection of water

rights. The board also points out the importance of certain additional legislation authorizing the sale of surplus stored water and the modification of conditions of payments for water rights on certain projects which will otherwise fail of returning their cost to the reclamation fund. The Secretary of the Interior in his annual report to me has recommended similar legislation.

The board recommended the allotment of the $20,000,000 provided by the act of June 25, 1910, to the following-named projects:

Salt River, Ariz	$495,000
Yuma, Ariz. and Cal	1,200,000
Grand Valley, Colo	1,000,000
Uncompahgre, Colo	1,500,000
Payette-Boise, Idaho	2,000,000
Milk River, Mont	1,000,000
North Platte, Wyo. and Nebr	2,000,000
Truckee-Carson, Nev	1,193,000
Rio Grande, N. Mex., Tex., and Mex	4,500,000
Umatilla, Oreg	325,000
Klamath, Oreg. and Cal	600,000
Strawberry Valley, Utah	2,272,000
Sunnyside, Tieton—Yakima, Wash	1,250,000
	665,000
Total	20,000,000

and that the interest on the loan as provided by said act be charged against the projects on the amounts contributed for their completion.

The recommendation of the board for the tentative allotment of the general reclamation fund among the various projects for the years 1911 to 1914, inclusive, was as follows:

Yuma	$2,380,462
Grand Valley (conditional)	500,000
Uncompahgre	2,045,000
Minidoka	528,000
Payette-Boise	4,585,435
Huntley	110,000
Milk River	2,950,000
Sun River	3,278,000
Lower Yellowstone (conditional)	578,000
North Platte	2,185,000
Truckee-Carson	1,594,000
Rio Grande	1,855,000
Missouri pumping (conditional)	270,000
Belle Fourche	480,000
Okanogan	13,000
Shoshone	2,000,000
Total	25,351,897

No allotments either from the loan or from the general reclamation fund were recommended for the following projects, except for necessary maintenance and operation: Orland, Cal.; Garden City, Kans.; Kittitas, Wapato, Benton (Yakima project), Wash.; Carlsbad, N. Mex.; Hondo, N. Mex.

The last-named projects are, with the exception of the Kittitas, Wapato, and Benton units of the Yakima project, completed or nearly completed. With respect to the said three units of the Yakima project, the board recommended development of a general system of storage reservoirs for the Yakima Valley, provided Congress authorizes the sale of excess stored water, so that the return of the cost of building of reservoirs may be secured, but did not recommend any

allotment of funds for the construction of reservoirs or canals specifically for the said units.

After careful consideration of the report of the Board of Engineers, I approved the same, believing that it sets forth a plan for the distribution of the loan and of the available reclamation fund, that, from an engineering and economic standpoint, will best secure the speedy completion of those projects, which, because of their character, the needs of the settlers, treaty or interstate relations, protection of water rights, and prompt return to the reclamation fund of the moneys invested, should be given the preference in construction and completion over such projects or parts of projects which are more remote and may properly wait until a later date for construction or may secure water through private canals in the event the Government is authorized to dispose of surplus water to the owners of such canals. My approval, however, is subject to the condition that the amounts allotted to the various projects may be adjusted and modified from time to time, as is found necessary for the intelligent and proper prosecution of the work and the advantage of the service. I have authorized the Secretary of the Interior to call upon the Secretary of the Treasury from time to time, as the same are needed, for the funds provided for by the act of June 25, 1910, in accordance with the allotments recommended by the board and approved by me.

Pursuant to the recommendations of the Secretary of the Interior and of the Board of Army Engineers, I earnestly recommend the enactment of a law which will permit of the disposition of any surplus stored water available from reclamation projects to persons, associations, or corporations operating systems for the delivery of water to individual water users for the irrigation of arid lands and the enactment of legislation which will give executive authority for the modification of conditions of payment for water rights on certain of the projects where, by reason of local conditions, the return of the cost of the projects to the reclamation fund will not be secured unless settlers are permitted to make payments on terms or conditions other than those specified in the public notices heretofore issued. In this connection attention is directed to the provisions of Senate bill 6842 now pending. Attention is also directed to the other legislation pertaining to reclamation projects recommended by the Secretary of the Interior, which legislation would aid in the administration of the reclamation projects.

With the funds now at our disposal and the enactment of the additional legislation suggested, it is hoped that the work upon the several projects for which allotments have been made, may proceed to an early completion and that the settlers and water users upon the projects upon being furnished with water for the irrigation of their lands may be enabled to return to the Treasury the sums expended in the construction of the projects. In accordance with the requirements of section 2 of the reclamation act, the Secretary of the Interior has already transmitted to Congress the ninth annual report of the Reclamation Service, and in order that Congress may be placed in possession of all the information at hand to date with reference to the reclamation projects and the estimated cost of their completion I transmit herewith for its further information a copy of the said report of the Board of Army Engineers.

Wm. H. Taft.

The White House, *January 5, 1911.*

REPORT OF THE BOARD.

SECTION I.

LETTER OF TRANSMITTAL.

WASHINGTON, D. C., *November 28, 1910.*

The board of officers of the Corps of Engineers of the United States Army detailed to inspect the various reclamation projects has the honor to submit the following report:

2. The board was convened by Special Orders No. 156, War Department, July 6, 1910, and directed to report to the Secretary of the Interior. The duties of the board, as originally outlined, are contained in the following letter of instructions:

DEPARTMENT OF THE INTERIOR,
Washington, July 21, 1910.

Col. JOHN BIDDLE,
Corps of Engineers, United States Army,
President Board of Army Engineers on Reclamation Projects,
Washington, D. C.

SIR: I have the honor to instruct the Board of Army Engineers, constituted under the provisions of an act of Congress, entitled "An act to authorize advances to the reclamation fund * * * and for other purposes," approved June 25, 1910, as follows:

The act itself indicates the scope and functions of the board in the following language: "*And provided further*, That no part of this appropriation shall be expended upon any existing project until it shall have been examined and reported upon by a board of engineer officers of the Army, designated by the President of the United States, and until it shall be approved by the President as feasible and practicable and worthy of such expenditure; nor shall any portion of this appropriation be expended upon any new project," and is interpreted by me to require such examinations of existing projects and methods, and of works and layouts on the ground as will enable the board to intelligently judge of the practicability of the project in an engineering sense, and to report facts and opinions deduced therefrom, in sufficient detail, to enable the President to judge finally of the feasibility and worthiness of such project in an economical sense.

The board will, at their meeting in Washington, consider such information, including printed or written projects, maps, and oral statements, as may be obtained by them, and will thereafter report on any projects that in their opinion may be finally reported upon without personally visiting the localities involved.

It will visit as a board, or by subdivisions of the board, any and all projects concerning which the information obtained is inadequate or unconvincing to the board; and in making such personal visits, inspections, and investigations the board, or its subdivisions, will first visit preferably the projects upon which work is most urgently demanded and in the order of urgency, whenever in its opinion the time and expense required in the examination in such order may justify.

Final reports of the board on individual projects should be sent in as soon as practicable after conclusions are arrived at to me, through Gen. Marshall, consulting engineer, who will indorse his views upon each report in forwarding it to me.

The board will determine for itself the projects to be actually visited and the order in which they will examine them with least hindrance and delay to the work of the Reclamation Service and of the War Department.

The members of the board will, when on duty under this detail, be paid their mileage from the reclamation fund. All other necessary expenses will be paid them through the War Department.

Such civilian clerks, qualified as stenographer and typewriter, as may be necessary will be detailed to accompany the board.

This order is in lieu of order approved July 6, 1910, which order is hereby vacated.

Very respectfully,

FRANK PIERCE,
Acting Secretary.

Approved:
WM. H. TAFT,
July 28, 1910.

3. These written instructions were subsequently supplemented by oral instructions to investigate all matters connected with the Reclamation Service necessary to enable the board to report fully as to the conditions and needs of each project; to make recommendations as to the abandonment, continuation, or completion of each project; and as to the allotment of funds for future work, both from the regular reclamation fund and from the $20,000,000 loan.

4. The board met in Washington, D. C., July 20, 1910, and undertook a general study of the scope and conditions of the various projects as set forth in the printed reports and records of the Reclamation Service, supplemented by oral statements of the director made at the request of the board. As a result of the preliminary studies it was deemed advisable to inspect all of the projects before submitting a report. These inspections were made between July 28 and October 22, 1910, and, with a few exceptions, all of the projects were visited by all members of the board. Public hearings were held on each project.

5. The board was accompanied by the consulting engineer to the Secretary of the Interior and over most of the projects by the Director of the Reclamation Service. In each of the six geographical divisions into which the work is divided the board was also accompanied by the supervising engineer in charge of the division. The inspection of each project was made under the immediate guidance of the project engineer and his principal assistants. Excellent facilities were furnished by the Reclamation Service, or through it by the citizens living on the projects, which enabled the board to examine thoroughly and quickly all desirable features, including both the engineering structures and lands. The various railroads passing through the projects gave the board every assistance for proceeding rapidly from point to point.

6. In its inspection the board was impressed with the ability of the employees occupying positions of responsibility and desires to record its appreciation of the assistance rendered by them.

7. At the requests of the board there was compiled for each project a memoir containing a history and description of the project and its principal features and pertinent information relative to water supply, lands, costs, and estimates. From these memoirs, supplemented by the annual reports and certain special communications, the statistical data in this report were obtained.

8. Before proceeding to the detailed consideration of each project attention will be invited to certain general features of the work of the Reclamation Service.

9. Twenty-five projects have been undertaken, which involve, including extensions, the irrigation of 3,200,000 acres of arid or semi-arid land, at a cost approximately estimated at $145,000,000. About $60,000,000 have been expended to date and about 600,000 acres are now receiving water. Only part of this area has been formally opened, the

remainder receiving water from the Reclamation Service on a rental basis or through private canals not yet absorbed in the projects.

The reclamation fund to date aggregates $65,700,000, which includes $964,393 received to September 30, 1910, on account of repayment of building charges. The accretions to the reclamation fund during the next four years, as estimated by the Reclamation Service, are as follows:

Years.	Sale of public land.	Repayments.	Total.
1911	$6,000,000	$1,000,000	$7,000,000
1912	5,500,000	1,500,000	7,000,000
1913	4,500,000	2,500,000	7,000,000
1914	4,000,000	3,000,000	7,000,000

11. *Structures.*—The engineering structures are, as a whole, well designed and well built. Some of them, as the Pathfinder Dam, the Shoshone Dam, the Roosevelt Dam, and the Gunnison Tunnel, are monuments reflecting great credit on both designer and builder.

12. Some of the high earth dams, such as the Belle Fourche Reservoir Dam, which has a cross section approaching the limit of safety; the Bumping Lake Dam, the material of which is not entirely suitable; and the Lower Deer Flat Reservoir Dam, where the leakage is considerable, should be kept under close observation.

13. In some cases, for example, as the Lower Yellowstone Dam and the Laguna Dam, it is believed that equally suitable structures could have been constructed at less cost. At one or two places work has been pushed to completion under difficulties due to floods and weather, when reasonable delay would have effected a considerable saving without great detriment to the project.

14. Modern irrigation being a relatively new art in this country, much freedom was allowed local engineers in the design of minor structures. While this was a wise policy in the early stages of this work, it has resulted in some complicated and unnecessarily expensive structures. With the present knowledge of the comparative merits of the different types, it is believed that standard designs of the simplest satisfactory type should be adopted for all minor structures.

15. *Water supply.*—The most uncertain feature of nearly all the projects is the water supply. This is under State control, and in the prosecution of its work the Reclamation Service bears the same relation to the State as a private individual or corporation. In each case the filings have been made under State laws, and in some States special legislation has been enacted to prevent future encroachments on the filings of the Reclamation Service. All of the filings made by the Reclamation Service are, however, subject to the prior filings made by individuals and corporations. Where the water rights have been adjudicated the rights of the United States are well defined, but elsewhere they are uncertain and may prove to be materially different from that assumed.

16. It is recommended that, wherever possible, steps be taken to secure an early adjudication of water rights on all projects where such adjudications have not yet been made, and that, pending such action, expenditures be kept within the probable rights of the United States.

17. On some projects there is a surplus of stored water, which could be advantageously sold if that course were authorized by law. Legislation with this object in view is now pending in Congress. If the sale of surplus water were authorized, certain proposed extensions to cover private land by means of pumping could well be left to private enterprise.

18. *Land.*—In nearly all projects the land proposed to be irrigated will, with proper cultivation and treatment, bear the construction and operation and maintenance charges. In a few cases the payments will be burdensome. In the Garden City and Missouri River pumping projects it is asserted by the settlers that the cost of pumping is prohibitive, but with better farming methods this condition may be changed.

19. Some complaint was made that the adopted sizes of farm units on public land are too small. These vary from 10 acres on part of the Umatilla project to 40 and 80 acres on most of the others. The size of the farm unit was fixed after consideration of the productiveness of the soil, the climate, and the value of the crops that could be raised, the intention being to limit it to an area sufficient for the support of a family. In a few cases there appeared to be some justification for the complaints, but further experience is desirable before any general changes are made.

20. Several Government demonstration farms are maintained by the Reclamation Service at the expense of the projects on which they are located. As a rule, they are not self-supporting, and though the cost to the settlers is not large they form a cause of discontent. Except when self-supporting and needed to supply vegetables and forage for Government use, it is believed that the maintenance of such farms should be left to the Agricultural Department.

21. *Cost.*—The actual cost of completed work has almost invariably exceeded the original estimates, and in the case of some structures has been two or three times as large. This increase in cost has been the cause of much of the discontent among the settlers. It was partly due to a general increase in the cost of labor and materials, partly to underestimates and an insufficient allowance for contingencies, and partly to the necessity of doing more work than was originally contemplated.

22. *Estimates.*—The estimates of cost for completion adopted by the board are taken from the reports submitted by the supervising engineers, supplemented by estimates furnished by the Director of the Reclamation Service. These estimates are based on the experience gained on work already done. In some cases they are approximate only, and will require modification after further surveys and studies are made.

23. Some increase in estimates may be necessary, due to insufficient allowance for drainage. This is an important feature of the reclamation work, particularly when the farmers are not experienced in the economical use of water. The actual needs of the work in this respect can seldom be foreseen with any definiteness, and in consequence drainage on many of the projects has been left to be developed as the need arises.

24. In only a few of the estimates submitted by the Reclamation Service has any allowance been made for an interest charge. As interest at the rate of 3 per cent must, under certain conditions, be

paid on the whole or part of the $20,000,000 loan authorized by Congress to the reclamation fund, some additions to the estimates on this account will probably be necessary. Assuming that expenditures from this fund are made at a uniform rate during five years, that the repayments to the Treasury are made at a uniform rate during the following five years, and that interest must be paid for the entire period, the total interest charge would be equivalent to 3 per cent on $10,000,000 for 10 years, or $3,000,000. As it has not yet been determined whether this interest charge is to be spread over all the projects or parts of projects upon which the building charge has not yet been announced, or whether it is to be confined to projects upon which the loan is used, it is impracticable to state its effect on any particular project. It is believed, however, that the result of this added charge, whichever method is adopted, will not be sufficient to adversely affect the feasibility of any of the projects from an economic standpoint.

25. *Returns to the reclamation fund.*—The reclamation act contemplates the return to the fund of the estimated cost of the different projects and the work has been prosecuted on that basis. The estimated cost is held by the Reclamation Service to be that officially announced by the Secretary of the Interior when the project is opened, and not the preliminary estimates made when the project was undertaken, as was assumed by many of the owners of private lands within the projects. On the assumption that the announced building charge is the estimated cost contemplated by the act, the losses to the reclamation fund, except on four of the projects, which will be referred to hereafter, will be relatively small, though, by reason of the number and large size of some of the projects undertaken, the repayments will extend over many years. If, on the other hand, the term "estimated cost," as used in the act, should hereafter be judicially determined to mean the preliminary estimate made when the project was undertaken, very large losses to the fund will occur.

26. In many of the projects the announced building charge on certain units has been less than the actual cost, but it is expected to compensate for these losses by making the building charge on remaining units correspondingly larger than the actual cost. In the case of public lands such adjustments can undoubtedly be made, but in the case of private lands it is questionable whether they can be required to pay any more than the proper proportion of the actual cost of the work pertaining to the unit in which the lands are situated. If this be true, the probable losses to the fund will be considerably greater than is indicated in the detailed reports.

27. On nearly all of the projects the Reclamation Service deals with the landowner through a water users' association. This is an incorporated body, in which each member holds as many shares of stock as he has acres of irrigable land within the project. In most of the associations the par value of the stock was fixed at what was apparently the originally estimated construction charge per acre. The land covered by the stock subscriptions of its members is bound by means of a contract between the association and the Reclamation Service.

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28. The associations being formed in different States, vary in character and the contracts are not all alike. In most of them, however, it is provided that upon the formal opening of the project each holder of stock shall make a water-right application. If he does so, his land becomes bound for the repayment of the announced building charge. If he fails to do so, he can be dropped from the association and the lien foreclosed, but the liability in this case is apparently limited to the par value of the stock.

29. As the probable construction charges on many uncompleted projects will exceed the par value of the stock of the Water Users' Association, due regard for the security of the investment requires that the par value of the stock be correspondingly increased or other means taken that will accomplish the same purpose.

30. A positive loss will occur on the lower Yellowstone project even under the most favorable conditions of completion, and in the Missouri River and Garden City pumping projects and in the Hondo project large losses appear to be inevitable.

31. Under existing regulations the construction charges must be returned to the reclamation fund in 10 equal annual payments. This is regarded as a hardship by the settlers on some projects, who expressed a desire for a series of graduated construction payments increasing from 1 or 2 per cent the first year to 14 or 15 per cent the tenth year. Should this suggestion be generally adopted, it would mean a delay of several years in the return of the first half of the investment and a corresponding delay in the completion of other work.

32. On some of the projects in the semiarid regions such a modification in the terms of payment may be necessary to prevent an absolute failure of the project, but the general adoption of a system of graduated payments is not believed to be necessary or advisable.

33. *Ownership of land.*—Table No. 1 shows the amounts of public, State, and private land under the various projects. By public land is meant land in Government ownership, which has been or can be filed on subject to the terms of the reclamation act. In some cases land was entered shortly before withdrawal of adjoining land under the expectation that the project would be undertaken. The title in these cases did not become vested in the homesteader until several years after work on the project had been started, and in a sense such lands were quasi public. At that time, however, as the owners were under no obligation to enter the project and as they could not be compelled to reduce their holdings below the acreage specified for private lands, the lands so held were essentially in private ownership and have been so classed. It is stated by the Director of the Reclamation Service that the area of land so entered is not large.

34. State lands included within a project are not, as a rule, bound to repay the construction charge. In many cases, however, the State has agreed to dispose of its land in tracts of the size adopted for the farm units with the provision that the purchaser shall apply for water and assume the building charge. There is no method of enforcing the sale of such lands nor any assurance that they will be sold within a given time. In some instances, delays of this character may adversely affect water rights and delay or reduce anticipated returns to the reclamation fund. Closer cooperation between the State and the Nation seems desirable.

35. In forming its opinion as to the merits of the different projects, the board has been guided by the following general considerations:

(1) Feasibility from an engineering and an economic standpoint.

(2) Character from a geographic standpoint, whether international, interstate, or intrastate.

(3) The relative amount of public land entered or subject to entry under the reclamation act.

(4) The amount of money already expended and the necessity of completion in order to insure its return, regardless of the second and third considerations.

(5) The protection of water rights pertaining to desirable extensions as contemplated by the act of Congress authorizing advances to the reclamation fund.

(6) The existence of agreements with water users' associations, private individuals, and corporations.

36. In making the amount of public land one of these considerations the board is actuated by the belief that the primary object of the reclamation act was the reclamation of public land with incidental benefits to such adjoining private land as must, in nearly all cases, be included in the project in order to make it feasible from an economic or an engineering standpoint.

37. While the community as a whole will profit by the reclamation of private lands, the greater portion of the benefits resulting from such expenditures of Government funds accrues to the original owners, and this without any investment on their part. For instance, in the Tieton unit of the Yakima project, which involves only 6 per cent of public land, the inauguration of the project increased the value of private holdings from a merely nominal sum to about $150 per acre. These private holdings, some of which were large, are being divided up and sold to settlers, who will be required to pay the construction charge of $93 in addition to the above price.

38. In undertaking projects where the direct Federal interests are small it would seem no more than equitable to add an interest charge to the cost of reclaiming private land or to require that a percentage of the private holdings be deeded free of cost to the United States, the areas so deeded to be subsequently thrown open to entry under the homestead law as modified by the reclamation act.

39. A description of the various projects containing the recommendations of the board follows. It is supplemented by Table No. 2, giving the total estimated cost of each project, the allotments to date, and the suggested allotments.

Respectfully submitted.

JOHN BIDDLE,
Lieutenant Colonel, Corps of Engineers.
W. C. LANGFITT,
Lieutenant Colonel, Corps of Engineers.
WM. W. HARTS,
Major, Corps of Engineers.
C. W. KUTZ,
Major, Corps of Engineers.
H. BURGESS,
Major, Corps of Engineers.

The SECRETARY OF THE INTERIOR
(Through Consulting Engineer to the Secretary of the Interior).

TABLE No. 1.—*Lands.*

[To accompany Section I.]

Projects.	Total area.	Public lands subject to reclamation act.	Private lands.	State and school lands.	Lands under irrigation, 1910.	Lands open to entry, 1910.	Remarks.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	
Salt River	230,000	.....	216,000	14,000	127,000	.....	Area dependent on water supply.
Yuma	131,000	74,000	57,000	.....	7,000	.....	Includes mesa lands.
Orland	14,000	.....	14,000	.....	.....	.....	Proposed extensions not included. Partly under irrigation from privately operated ditches.
Grand Valley	53,000	30,070	22,930	.....	.....	.....	
Uncompahgre	140,000	34,000	106,000	.....	40,000	.....	Present irrigation largely from private ditches.
Minidoka	124,500	101,600	3,100	19,800	62,000	.....	
Payette-Boise	243,000	85,820	127,130	30,050	30,000	.....	
Garden City	10,655	.....	10,655	.....	.....	.....	Part of land irrigated with flood water.
Huntley	32,844	28,754	4,090	.....	12,000	6,000	
St. Mary Milk River	196,000	76,000	110,000	10,000	8,000	.....	Area dependent on water supply. Irrigated at present with flood water.
Sun River	322,000	244,500	52,500	25,000	11,000	2,743	Area may be largely reduced on account of water supply.
Lower Yellowstone	62,280	17,000	43,280	2,000	7,000	1,600	
North Platte:							
North Side (interstate)	129,270	83,358	34,864	11,048	51,218	3,465	
Goshen Park	210,000	152,900	44,100	13,000	.....	.....	Area indefinite, as surveys are incomplete.
Truckee-Carson	206,000	120,000	86,000	.....	32,000	.....	Area dependent on water supply.
Carlsbad	20,047	20	20,027	.....	14,000	.....	
Hondo	10,000	240	9,760	.....	.....	.....	A small area irrigated with flood water.
Rio Grande:							
New Mexico	110,000	12,000	98,000	.....	50,000	.....	Irrigated lands lie both in Texas and New Mexico.
Texas	45,000	.....	45,000	.....	.....	.....	
Missouri pumping:							
Buford-Trenton	12,035	1,400	10,635	.....	400	.....	
Williston	11,147	1,000	10,080	67	2,000	.....	
Umatilla	25,000	4,120	20,880	.....	15,319	2,000	Does not include proposed extension.
Klamath:							
Lower project uplands	37,000	700	36,300	.....	18,471	.....	}
Tule Lake	35,000	31,900	3,100	.....	.....	.....	} Lower Klamath Lake marsh lands omitted.
Upper subproject	16,000	1,500	14,000	500	.....	.....	}
Modoc subproject	18,000	9,000	8,000	1,000	.....	.....	}
Bellefourche	100,000	44,500	50,000	5,500	23,500	2,946	
Strawberry Valley	60,000	.....	60,000	.....	30,000	.....	Does not include proposed extension.
Okanogan	8,650	1,100	7,550	.....	4,000	.....	Do.
Yakima:							
Sunnyside	98,596	1,346	95,980	1,270	50,000	.....	
Tieton	34,500	2,034	30,184	2,282	.....	.....	In part under flood irrigation.

Kittitas	67,890	4,240	61,410	2,240	.....	.....	
Wapato	114,000	.....	114,000	.....	.....	.....	This is all Indian land and partly under flood irrigation.
Benton	150,000	50,000	90,000	10,000	.....	.....	Land unsurveyed and areas approximate.
Shoshone	164,000	153,000	1,500	9,500	15,000	14,347	Area may be largely reduced on account of water supply.
Totals	3,241,414	1,366,102	1,718,055	157,257	609,908	.....	

TABLE 2.

[To accompany Section I.]

Project.	Total estimated cost.	Allotments to Dec. 31, 1910.	Allotments required to complete.	Allotments recommended 1911–1914, inclusive.		Required to complete after 1914.
				Fund.	Loan.	
Salt River	$9,665,000	$9,170,000	$495,000	.....	$495,000	(1)
Yuma	7,700,462	4,120,000	3,580,462	$2,380,462	1,200,000	(1)
Orland	607,335	608,000	.....	.....	.....	(1)
Grand Valley	3,621,663	225,000	3,396,663	[2] 500,000	[2] 1,000,000	[2] $1,896,663
Uncompahgre	9,000,000	4,455,000	4,545,000	2,045,000	1,500,000	1,000,000
Minidoka	4,505,000	3,977,000	528,000	528,000	.....	(1)
Payette-Boise	10,852,435	4,267,000	6,585,435	4,585,435	2,000,000	(1)
Garden City	419,000	419,000	.....	.....	.....	(1)
Huntley	1,040,000	955,000	110,000	110,000	.....	(1)
Milk River	6,891,000	941,000	5,950,000	2,950,000	1,000,000	2,000,000
Sun River	10,000,000	722,000	9,278,000	3,278,000	.....	6,000,000
Lower Yellowstone	3,523,000	2,945,000	578,000	[2] 578,000	.....	(3)
North Platte:						
Interstate	5,070,000	5,135,000	14,835,000	2,185,000	2,000,000	10,650,000
Goshen Park	14,900,000					
Truckee-Carson	7,000,000	4,213,000	2,787,000	1,594,000	1,193,000	(1)
Carlsbad	605,000	605,000	.....	.....	.....	(1)
Hondo	359,000	359,000	.....	.....	.....	(1)
Rio Grande	9,665,000	1,310,000	8,355,000	1,855,000	4,500,000	2,000,000
Missouri Pumping	1,195,000	983,000	270,000	[2] 270,000	.....	(3)
Umatilla	1,650,000	1,325,000	325,000	.....	325,000	(1)
Klamath	4,470,195	2,334,000	2,136,195	.....	600,000	1,536,195
Belle Fourche	3,150,000	2,670,000	480,000	480,000	.....	(1)
Strawberry Valley	3,407,000	1,135,000	2,272,000	.....	2,272,000	(1)
Okanogan	590,000	603,000	13,000	13,000	.....	(1)
Yakima:						
Sunnyside	3,148,000	4,711,000	18,145,000	.....	1,250,000	(1)
Tieton	3,185,000			.....	665,000	(1)
Kittitas	4,525,000			.....	.....	4,525,000
Wapato	4,205,000			.....	.....	4,205,000
Benton	7,500,000			.....	.....	7,500,000
Shoshone	7,828,000	3,828,000	4,000,000	2,000,000	.....	2,000,000
Total	.....	61,885,000	88,664,755	25,351,897	20,000,000	43,312,858

[1] Completed. [2] Conditional. [3] Completed; conditional.

NOTE.—The allotments to December 31, 1910, include allotments for operation and maintenance.

FINANCIAL SUMMARY.

Balance unallotted	$3,000,000
Estimated receipts 1911–1914	28,000,000
Loan	20,000,000
Total	51,000,000
Allotments recommended	45,400.000
Operation, maintenance, and contingencies	5,600,000
Total	51,000,000

SECTION II.

SALT RIVER PROJECT, ARIZONA.

1. The board visited the Salt River project on October 8, 9, and 10, visiting the Granite Reef Diversion Dam on October 8, the Roosevelt Storage Dam on October 8 and 9, and the irrigated lands in the vicinity of Mesa and Phoenix on October 10. A public hearing was held in Phoenix on October 10.

2. *Location and description.*—The Salt River project is one of the larger projects of the Reclamation Service and involves many

engineering features of magnitude and difficulty. It is located on the Salt River in the vicinity of the towns of Mesa and Phoenix, Ariz., and contemplates the irrigation of about 230,000 acres of land, mainly in private ownership.

3. From an early date efforts were made by private owners of lands in the vicinity of Phoenix to divert water from Salt River to their lands, and a series of canals and ditches were constructed both north and south of the river heading from various diversion dams. The earliest canal, called the "Swilling," was commenced in 1868. In the course of time many thousands of acres, finally amounting to 151,000, were irrigated in a more or less insufficient manner.

4. The present site of the storage dam was originally in the hands of private owners, who expected to use it for the construction of storage works at some future time. The frequent destruction of the diversion dams by floods and the lack of financial means among the owners to build and maintain better structures and to provide storage led the Reclamation Service to undertake this project.

5. The waters of the Salt and Verde Rivers are used for irrigation. Owing to the large discharge during certain periods of the year and the low discharge in others, storage was found to be necessary to regulate the flow, the amount of water available being sufficient to irrigate large areas if properly conserved.

6. The project includes, first, a storage dam; second, a diversion dam to divert water into the canal system; and third, a system of distributing canals, carrying the water over the project.

7. In operating the works stored water is released into Salt River as needed and flows for a distance of about 60 miles in the natural channel to Granite Reef Diversion Dam, where the river flow is diverted both to the north and south sides of the river into the distributing system. This water supply is to be supplanted by electric pumping over a considerable area. The works of the project are now nearing completion.

8. *Transportation.*—Several railroads traverse the project, which furnish facilities for the transportation of products, the most remote points of the project being less than 15 miles from some railway station.

9. *Construction features.*—The most important feature of the project, and the only one contemplated at the beginning, is the storage dam. This was formerly called the Tonto Dam, but is now known as the Roosevelt Dam, and is located in the canyon of the Salt River a few hundred feet below the mouth of Tonto Creek. It is built in a narrow rock gorge, is 278 feet high, 235 feet long on the bottom, and 1,080 feet long on top, including spillways, and 680 feet excluding them. It is curved in plan, with a radius of 480 feet, and has a gravity section. It is built of uncoursed cyclopean rubble, except the faces, which are laid in 2 and 3 foot courses. The material is a quartzite which was obtained from the excavation for the spillways, one of which is located at each end of the dam. The spillways are crossed by reenforced concrete arch bridges, connecting the top of the dam with the banks and providing a roadway across the river along the top of the dam.

10. In the construction of this dam, which contains 341,244 cubic yards of masonry, a number of preliminary steps were necessary. A freight road to Mesa, 60 miles long, was built, one to Globe, 40 miles

long, and one to the nearest body of timber, about 30 miles distant, where 3,000,000 feet of lumber were cut on the public forest reserve for use on the project.

11. The high expense of transporting cement induced the reclamation engineers to build their own cement mill, after having found satisfactory material near by. This mill was put in operation in 1905, and supplied 338,452 barrels of cement. The total cost of this mill and its operation is given as $1,055,146, or about $3 per barrel.

12. Owing to the scarcity of fuel, power was supplied from a power canal about 19.5 miles long, taking water from the Salt River. The capacity of this canal is 250 second-feet, and it utilizes a fall of 226 feet. It was built through very difficult country and has 21 tunnels and 3,600 feet of twin concrete-steel conduits. It developes 4,400 horsepower.

13. The results seem to justify the wisdom of these steps. Considerable saving in the cost of cement is reported to have been made, and the electrical power was almost wholly depended upon during construction. When not needed at the dam site this power will be sold in the towns of Phoenix and Mesa, thus diminishing the expense of operation and maintenance after the completion of the system.

14. Sand for mortar and concrete was obtained by crushing the quartzite and dolomitic country rock for which sand crushers were installed.

15. Work on the dam under the contract was begun in 1905, and is now nearly finished. Its cost has been $3,009,991.33. The capacity of the reservoir is 1,284,000 acre-feet. Its area is 16,320 acres. Water may be released from the reservoir at three levels—first, through the sluicing tunnel in the bottom of the dam, by which the reservoir may be emptied; second, by the steel penstock, 10 feet in diameter, which is to supply water for the power house; third, a tunnel on the right bank at an elevation of 115 feet, to which water is to be admitted through three cast-iron pipes, 5 feet in diameter.

16. The water released from the storage dam is diverted into the distribution canals by the Granite Reef Diversion Dam. This dam is of mass concrete and raises the water surface 20 feet. It is an overflow weir, 1,000 feet long, 26 feet high, and has an apron 75 feet wide and 18 inches thick. At each end are canal headworks provided with sluicing gates in the main dam to remove silt from the canal entrance.

17. The canal system has practically all been purchased. The canals on the north side were bought by the Reclamation Service for $314,160.99, including the Arizona, Grand, Maricopa, Salt River Valley, and Cross-Cut Canals. Of these, the Arizona and Grand Canals are now being enlarged. On the south side of the river a new canal, called the South Canal, was built for a length of about 2 miles, to connect with the existing south-side system. Near its lower end a temporary by-pass admits water into the Consolidated Canal, supplying a private system, which was purchased for $187,000. This Consolidated Canal supplies the Utah and Mesa Canals and part of the Tempe Canal, and is now being enlarged. The East Canal heads in the South Canal near the by-pass, and has been constructed by the Reclamation Service. This was started under the " Certificate " plan of compensation, but this method of payment was stopped after $34,615.87 had been expended, and the canal was completed by the contractor at his own expense, and then sold to the Government for

$89,954.56. The minor structures now being built in the distribution system are usually of concrete and are simple and effective. In general, the engineering works on this project show careful design and construction.

18. *Water supply.*—Water is obtained for this project from the Salt and Verde Rivers, and from wells. Salt River has a drainage basin of 6,260 square miles, and the Verde River of 6,000 square miles, the average rainfall being 15 inches. The average annual run-off of Salt River at Roosevelt Dam is 800,000 acre-feet, and of the Verde River at McDowell, 580,000 acre-feet. The run-off fluctuates widely throughout the year, and the annual fluctuations are also large. From the Verde River only the unregulated flow is at present available. On Salt River, as already stated, storage has been provided in Roosevelt Reservoir for 1,284,000 acre-feet.

19. Discharge measurements of these rivers have been made since 1889, and assuming the reservoir as built at that date studies have been made by the Reclamation Service of the amount of water that would have been annually available from the unregulated flow of the Verde River and the annual draft on storage water necessary to supply an annual use of 760,000 acre-feet, this being the amount required for 190,000 acres at the assumed duty of 4 acre-feet per acre.

20. These studies show that during 15 years of the 20-year period under consideration there would have been a sufficient supply of water. During the remaining years, with an assumed evaporation loss of 4.42 feet, there would have been shortages as shown in the following table:

	Per cent.
1900	9
1901	6
1902	45
1903	28
1904	38

21. The evaporation loss of 4.42 feet per annum is that recently determined by the director of the experiment station at Tucson, Ariz., and is the net loss after subtracting the rainfall. Former measurements extending over a number of years indicated an evaporation loss of 7.58 feet. Had this loss been assumed, the shortages above indicated would have been correspondingly increased.

22. The above studies are also based upon the right of the United States to impound in Roosevelt Reservoir for use in the project the entire flow of Salt River at this point. This right, however, will not exist unless all of the irrigable land in the valley possessing prior water rights becomes a part of the project. By an adjudication of the water rights in this valley, dated March 1, 1910, the various claims to the flow of the Salt and Verde Rivers are defined as to amount and priority. These claims cover 151,000 acres of Class "A" land and a diversion of 45,325 miners' inches, equivalent to 1,133 second-feet. This adjudication limits the right to impound water in the Roosevelt Reservoir in the following terms:

The daily flow in the Salt River shall not be impounded by the Government by means of the Roosevelt Dam in the reservoir, except when the total intake in such reservoir, including the estimated loss thereto by seepage and evaporation between such intake and the conflux with the Verde River, added to the flow of the Verde River shall exceed the amount called for in Table 10 (45,325 miners' inches) plus the amount to be added thereto for loss by evaporation

and seepage in the canals, unless at the request or with the assent of the users of such water whose land is entitled thereto; and no water user entitled thereto shall be deprived against his consent of his proportionate share of the normal flow of the river by reason of such impounding dam. The Government, in times of flood water, shall not, by impounding water in the reservoir, lessen the proportionate share of such flood water of any individual landowner not a member of the water users' association and against his consent, nor shall it lessen the proportionate share of the Tempe and San Francisco Canals, or of either of them, to such flood water available to such canals, so as to deprive such canals of such proportion of such flood water desired when the land lying under such canals is in need of such water or any portion thereof and can avail of it and when such canal company shall notify the commissioner of its desire to divert such water or any portion thereof. The various parcels of land in the valley in cultivation are entitled to share equally, according to acreage, in the use of the flood water available; the proportionate share in the flood water of the Tempe and San Francisco Canals is therefore to be measured by their relative acreage under cultivation, since the share of the land under the other canals listed in the association in the flood water in the Salt River can now be stored for them in the Roosevelt Reservoir. The acreage under the Tempe Canal is found to be approximately 16 per cent of the total acreage in cultivation. The acreage under the San Francisco Canal is found to be approximately 3 per cent of the total acreage under cultivation. The amount of flood water to which the Tempe and San Francisco Canals shall be entitled to receive, as above stated, is therefore 16 per cent and 3 per cent, respectively, of the total amount of flood water available.

23. A large percentage of the users of water are members of the Salt River Valley Water Users' Association, and as such have agreed to merge their water rights with those of the United States, but as there are at least 20,000 acres of land under the Tempe and San Francisco Canals not yet included in the project, it is evident that not all of the flow at the Roosevelt Dam can be impounded.

24. To what extent a strict compliance with the court's decree will affect the storage possibilities of the reservoir can not be determined from the information available, but it will probably necessitate reducing the area under the contemplated gravity unit by at least 10,000 acres.

25. In the adjudication referred to above the duty of water at the farm is assumed at 1 miner's inch continuous flow for each 160 acres, equivalent to about 5 acre-feet per acre per annum. To determine the amount to be diverted, seepage and evaporation losses in the canals are added at the rate of 1 per cent per mile. The Reclamation Service assumes a duty of 4 acre-feet per acre, which, in view of the character of the land and the length of the season, is believed to be small.

26. The shortage that would have existed in the past had the entire flow of the Salt River been impounded, the necessary reduction in the amount impounded to provide for prior rights, and the high duty of water assumed all lead to the belief that the water supply is insufficient for the proper irrigation of the 190,000 acres under the gravity unit.

27. *Lands.*—The proposed total acreage under this project is 230,000 acres, the area to be irrigated depending upon the quantity of the water supply available, which has not yet been fully determined. There is more land suitable for irrigation than can be supplied with water. All of the land is in private ownership, of which 14,000 acres are school lands. It is expected by the Reclamation Service that about 190,000 acres will be irrigated by gravity and the remainder by pumping from wells. The power which is available at various points of the project is to be developed and used for this purpose.

28. Already some pumping from wells has been done under private enterprise in the valley, lifting the underground water to the surface for irrigation. The results are sufficiently promising to warrant the extension of this practice if the wells are sufficiently free from salt to be used for irrigation. Some of these wells are found to be decidedly alkaline, but by mixing the well water with the canal water it is hoped that it will be sufficiently diluted to be suitable for irrigation.

29. The elevation of the irrigated lands is about 1,200 feet above sea level. The range of temperature is from 20 to 120° F., a mean of about 70°, and the rainfall over the irrigated area varies from 3 to 10 inches, being entirely too small for any cultivation. The lands have practically no value unless irrigated.

30. The duty of 4 acre-feet at the farm is small, in view of the character of the land and the length of the season, but is acceptable to people interested, who prefer irrigation on this basis rather than having a greater quantity over a smaller area. Two crops are often raised in the same season from the same area.

31. There are at present 127,000 acres under cultivation. This area is largely made up of lands heretofore irrigated under private systems, which are now being furnished water under the present project. The land is very productive. Over 50 per cent of this land is planted to alfalfa, and returns from six to seven cuttings annually, varying from one to two tons a cutting per acre. Considerable success has also been met in raising citrus fruits and dates.

32. The land is valued at from $100 to $400 per acre, the average being about $160 per acre. The higher price is asked for bearing orange groves. The average value of land before the project was commenced was about $45 per acre. There seems little doubt that the land is able to return to the United States a reasonable expenditure for irrigation. This amount has not yet been determined, but will probably be between $45 and $55 per acre.

33. Until recently, the lands of the project have been irrigated under private canal systems. Those farmers who were formerly furnished an inadequate supply of water were, in consequence, desirous of subscribing for the more reliable supply of the Reclamation Service system, and formed the Salt River Water Users' Association in February, 1903, to facilitate the construction of the project. Those who have withheld from subscribing their lands have generally earlier water rights and a satisfactory supply. About 218,000 acres are already under agreement to take water, but the land under the Tempe Canal, amounting to about 25,000 acres, has one of the best water rights and, except about 7,000 acres, has been withheld. About 5,000 acres under the San Francisco Canal have also not been subscribed, nor have the lands of the Indian reservation, lying at the eastern end of the Arizona Canal, which have been allowed a prior right to 700 miner's inches by court decision. It is expected by the Reclamation Service that much of this land, both private and Indian, will gradually come under the project.

34. *Cost.*—The total cost of this project up to June 30, 1910, has been $8,959,760.54. There has been allotted from reclamation funds $9,170,000. The project is over 80 per cent completed.

35. Under an agreement with the property owners under this project, an assessment of $4.50 per acre is to be made for the completion of the power plants and the enlargement and construction of

canals to expedite the work. This will avoid the necessity of obtaining more money from the reclamation fund for this purpose. In consideration of this contribution the opening of the project has been delayed two years. The work to be done with these funds is as follows: First, the construction of the Salt Lateral, a lined ditch about 2½ miles long; second, the completion and enlargement of the present Grand Canal; third, the construction of the new Crosscut Canal connecting the Arizona and Grand Canals; fourth, the construction of a power house to develop 6,000 horsepower between the new Crosscut and the Grand Canals; fifth, the construction of a power house between the South and Consolidated Canals to develop 3,000 horsepower; sixth, the construction of a power house at the Arizona Falls on the Arizona Canal to generate 700 horsepower.

36. The remaining work necessary and the estimate of cost are as follows:

Enlargement, Arizona Canal	$72,000
Pumping plants and wells, Messa district	48,000
Purchase Consolidated Canal	87,000
Materials	15,000
Power substation, Mesa	10,000
Waste gates, Arizona Canal	20,000
Wells and pumping plant, Tempe district	60,000
High Line Canal for drainage	65,000
Division gates, Consolidated Canal	8,000
Miscellaneous	35,000
	420,000

If the Tempe Canal comes in, the following will be needed:

Wells and pumping plants for drainage	$30,000
Power substation	25,000
High Line Canal for drainage	20,000
Total	495,000

This amount added to $9,170,000 already allotted will make the total cost of the work $9,665,000. If the area to be irrigated be taken at 230,000 acres, as now assumed by the Reclamation Service, the cost of construction will be about $42 per acre. This does not include $4.50 per acre voluntarily contributed by the water users' association to facilitate the completion of the project.

37. If the supply of water should be insufficient for the area of 190,000 acres assumed as the amount of land which can be irrigated by the gravity system, this price would need to be raised. The amount of water available for the areas to be irrigated by pumping is unknown, and if this should fall short the charge per acre to cover the cost of construction would need to be further raised. This increase might be as much as 25 per cent.

38. *Power.*—Water power will be developed at various points in the project, as follows:

(1) Roosevelt Dam, through reservoir, maximum horsepower, 5,200.

(2) Tempe Crosscut, maximum horsepower, 6,000.

(3) South Canal, maximum horsepower, 3,000.

(4) Arizona Canal Falls, maximum horsepower, 700.

At the dam the power canal now completed has a maximum horsepower of 4,400.

39. In purchasing the existing canal system certain obligations were assumed by the Reclamation Service for the supply of electricity to the Phoenix Railway & Light Co. The power canal used in the construction of the Roosevelt Dam is now applied to the generation of electricity for this company, with whom a 10-year agreement has been made, the electricity being furnished at the rate of 1½ cents per kilowatt hour for this period. No restrictions were included in this agreement as to the amount this company should charge the people of Phoenix. The receipts are used to diminish the operation and maintenance of the canal system.

40. The enlargement of the canals has been expensive, owing to the necessity of carrying on work while the ditches were in use, as the irrigation season lasts throughout the entire year on this project.

41. *Summary.*—(1) This project is located within the limits of the Territory of Arizona.

(2) The area in the project amounts to about 190,000 acres under the gravity system and about 40,000 acres by pumping. There is no public land subject to the reclamation act.

(3) It is doubtful whether the water supply is sufficient for the whole area proposed.

(4) The total estimated cost is $9,665,000, of which about $9,000,000 has been expended. The project is over 80 per cent completed.

(5) The land can readily return a cost of construction of from $45 to $55 per acre.

(6) The project is feasible both from an engineering and an economical standpoint.

(7) The large expenditures already made and the benefit that will follow completion make it desirable to continue work as rapidly as economically practicable until finished.

(8) Allotments: The following allotment is recommended for the four years, 1911–1914, inclusive:

From the loan	$495,000

Section III.

YUMA PROJECT, ARIZONA-CALIFORNIA.

1. This project was visited by the board on October 7, 1910, and a public hearing was held at Yuma in the evening of that day.

2. *Location.*—The project lies along the Colorado River between the Mexican boundary and a point 40 miles north of it, in Arizona and California. It is, therefore, interstate in character. The Southern Pacific Railway passes through the project from east to west, about one-third of the project lying to the north and two-thirds to the south.

3. *Description.*—A portion of the project, comprising 16,000 acres of Indian reservation land, lies in California, the remainder, 115,000 acres, lying in Yuma County, Ariz. Of this area, 55,000 acres are bottom lands between Yuma and the Mexican boundary; 20,000 are in the lower Gila Valley above Yuma; and 40,000 acres are mesa

lands south and east of Yuma. The water for the project will be taken from the Colorado River. The main engineering features of the project comprise a diversion dam in the Colorado River about 15 miles above Yuma; two main canals leading from it, one on each side of the river; a siphon across the Colorado River at Yuma; levees along the Yuma and Gila Rivers; and the subsidiary distribution systems. The canal leading from the dam on the California side of the river is the main canal of the project, having a capacity of 1,700 second-feet. As this canal passes through the Indian reservation laterals are led from it to irrigate the lands belonging thereto. At one point in this canal there will be a drop of 12 feet, at which it is proposed to develop 1,000 horsepower, which will be transmitted electrically and used to pump water for irrigating mesa lands. This canal is to be carried across the Colorado River in a concrete siphon, after which it divides and supplies water for the lands in the project below Yuma on the Arizona side of the river. The main canal on the Arizona side covers that portion of the project lying in the Gila Valley. The Laguna Dam, as the diversion dam is called, is of the Indian weir type and raises the water surface of the river at low water about 10 feet. In order to keep silt out of the canals, arrangements are made at the headworks on both sides of the river to admit only the upper layers of water and to sluice into the river below the dam any deposits in front of the canal headworks. The siphon consists of two shafts about 100 feet deep, one on each bank of the river, connected by a tunnel 14 feet in diameter, the shafts being 17 and 23 feet in diameter on the California and Arizona sides, respectively. There will be required 75 miles of levee to protect the irrigated areas, and of this amount 40 miles have been completed. A drainage system will also be necessary and is provided for in the estimates.

4. When this project was taken up there were in the valley four inefficient private irrigation systems, of which three were purchased by the Reclamation Service on account of their rights of way and the desirability of adding to the project the lands covered by them. One of these systems was operated by pumping, one had an abandoned pumping system, and one was a gravity system which had silted up. Since their purchase both pumping plants have been put in order and an additional pump added. The three pumps have been operated by the Reclamation Service. The first cost of these purchases was as follows:

Canal system and steam pumping plant	$63,260.60
Canal system and scoop wheel pumping plant	89,614.14
Additional pump	400.69
General expenses, undistributed	4,041.99
Total	157,317.42

5. *Water supply.*—The water supply is obtained from the perennial flow of the Colorado River without storage. Its drainage area comprises approximately 300,000 square miles. The rivers of the Colorado system receive their main supply from the melting snows on the mountains in Wyoming, Utah, and Colorado. The low-water discharge of the Colorado is from 3,000 to 4,000 second-feet, while the flood discharges, beginning in March and April and reaching the crest in June, may amount to 150,000 second-feet. The duty of

water is taken as 5.5 acre-feet per acre per year. The following table, furnished by the Reclamation Service from records made by its officials during 16 years, indicate the excess of water over that required by the project in the minimum monthly flow of the Colorado River at Yuma:

Month.	Minimum run-off (acre-feet).	Duty in feet.	Area of possible irrigation.
January	185,407	0.20	927,000
February	182,531	.25	730,000
March	367,702	.30	1,220,000
April	479,663	.41	1,170,000
May	1,670,000	.52	3,200,000
June	2,550,000	.70	3,650,000
July	1,411,995	.90	1,570,000
August	598,366	.80	750,000
September	386,456	.56	690,000
October	494,160	.38	1,300,000
November	321,271	.26	1,230,000
December	266,598	.22	1,210,000

Area in project, 131,000 acres.

The amounts in the second column are the minimum run-offs that occurred during the months named in the 16 years of observation. There will be, therefore, ample water for the project, after satisfying prior rights, to cover 200,000 acres now irrigated under private enterterprise in the Imperial Valley below. The Imperial Valley Irrigation Co. has filed on 10,000 second-feet additional, but as beneficial use of it has not yet been made, the claim will probably not be allowed in full, but restricted to an amount that will cause no interference with the Yuma project.

6. *Lands.*—The irrigable land in the different units is as follows:

Units.	Public.	Private.
Gila Valley	10,000	10,000
Yuma Valley	10,000	45,000
Mesa lands	38,000	2,000
Indian lands	16,000	.....
Total	74,000	57,000

The average size of the private farms in the project is 120 acres. The average annual rainfall over the irrigable area is 2½ inches and its elevation above sea level is from 100 to 300 feet. Dry farming is not possible. The climate is semitropical, though temperatures below freezing have occurred. All the lands in this project except the mesa lands are "valley" lands of great depth and richness, and it is expected that they will produce alfalfa, grains of all kinds, pears, dates, figs, apricots, melons, citrus fruits, vegetables, grapes, small fruits and berries, and cotton. By proper alternation two or more crops a year can be grown. From 5 to 7 cuttings of alfalfa per year are usual. At the present time this is the only single crop of consequence, there being 1,500 acres devoted to it. In 1909 the gross value of the crops on the 7,000 acres irrigated by pumping was $87 per acre. Lands are now worth from $50 to $100 per acre without water, and land in alfalfa is selling at from $150 to $200 per acre. Citrus-

fruit lands will be much higher. The mesa lands are especially adapted to these fruits. There would seem to be no question but that the land will be able to bear the construction cost, and this was emphatically so stated at the public meeting, the main desire of all being the early completion of the work.

7. Drainage is necessary in some parts of the project, for which the United States will construct only the main ditches. Levees, as stated above, are necessary along the Gila and the Colorado Rivers to prevent overflow. The cost of both the drainage and the levees is included in the estimates of the cost of completion.

8. *Lands now irrigated.*—In the Yuma Indian Reservation there are 700 Indians. The law gives each Indian 5 acres, or a total of 3,500 acres, leaving 12,500 acres for settlement, but on account of the possibility of an increase of the acreage allowed to each Indian, only 6,500 acres have been opened for settlement. This was done in March last, and since then the land has all been taken up in 173 farms of approximately 40 acres each. During this year 425 acres were irrigated, and this amount will rapidly increase in succeeding years. The maintenance charge has been fixed at $1 per acre.

9. No part of the main system has yet been opened, nor has any building charge been fixed nor any water supplied by gravity from the dam, except to the Indian lands above noted. The two pumping systems purchased and the one small additional pump fitted up and operated by the Reclamation Service furnish an inadequate supply to 7,000 to 10,000 acres. The charge for this service has been about $1 per acre-foot, at which price, it is stated, the cost to the landowners will be from $5.50 to $10 per acre this year.

10. *Costs.*—The expenditures on this project to June 30, 1910, have been $3,714,462.08, of which $441,513.71, or 11.9 per cent, was for field engineering and superintendence; $87,607.42, or 2.5 per cent, for clerical services on the project; $24,787.72, or 0.7 per cent, for the supervising engineer's office; and $90,665.87, or 2.5 per cent, for the Washington and Chicago offices, expert engineers, etc. The estimate of the additional expenditures required to complete the project is given in the following table:

Siphon connections, etc	$43,000
Dam and main canal to Indian reservation	230,000
Main canal to siphon	540,000
Indian reservation canal	75,000
Colorado siphon and wasteway	165,000
Main canal and laterals in Yuma Valley	800,000
Drainage systems	150,000
Rights and property	175,000
Gila Valley main canal and laterals	340,000
Levees	368,000
Mesa land pumping station	500,000
Mesa land main and lateral systems	600,000
Total	3,986,000

The total estimated cost of the project is, therefore, $7,700,462.08.

11. *Returns to the reclamation fund.*—So far only 6,500 acres have been opened and construction charge for them has been fixed at $55. The returns from this area will be $357,500. The estimated total cost of completion is $7,700,462.08. Subtracting $357,500 from this leaves $7,342,962.08 to be obtained from the remaining lands, amounting to 124,500 acres. The building charge for these lands must therefore

be about $60 per acre, providing all lands, including the remaining Indian lands, pay full construction charges and the estimates for completion is not exceeded. There is no definite agreement with the Indian Service, and any other course would result in either the settlers paying an increased cost or the United States losing a portion of its investment. The mesa lands, comprising 40,000 acres, are not definitely included in the project, although California Canal, its head works, and the siphon have had given them, so far as constructed, sufficient capacity to carry the additional water for these lands. The omission of these lands will reduce the total cost by $1,100,581, but will increase the cost per acre on the remainder from $60 to $73. It would, therefore, seem desirable to include them in the project. Only about 5,000 acres within the project have not applied for water under the reclamation act.

12. *Comment.*—The engineering structures are well designed and constructed. The Laguna Dam diverting the water of the river into the two main canals is especially noteworthy. Its cost, however, was approximately $350 per foot of length, and it is thought that a less expensive dam might have served the purpose equally well. This was one of the first projects undertaken by the Reclamation Service. The farmers have long been expecting water, and it was stated that promises were made that water would be available by the time first named in the contract for the completion of the Laguna Dam, July 19, 1907. The contractors finally failed on this dam and it was completed by force account on March 20, 1909. Water, however, can not be supplied to their lands until the completion of the siphon, now under way, and the connecting canals. It is understood that the delay has been due to lack of funds. The main problems have all been solved. It is now simply a question of completion of more or less minor works whose total cost aggregates nearly $4,000,000.

13. *Summary.*—(1) The Yuma project is feasible, both from an economic and an engineering standpoint.

(2) It is interstate in character, lying in both California and Arizona.

(3) Of the 131,000 acres in the project, 74,000 acres, or 56.5 per cent, are public lands subject to the reclamation act.

(4) The water supply is sufficient.

(5) The total estimated expenditures on this project are $7,700,462.08, of which $3,714,462.08 were expended to June 30, 1910.

(6) The construction charge, approximately $60 per acre, can readily be borne.

(7) The project is an important one and worthy of early completion.

(8) The question of payment of construction charges by the remaining Indian lands should be determined.

(9) The mesa lands should be definitely included in the project.

(10) The following allotments are recommended for the four years, 1911–1914, inclusive:

From the fund	$2,380,462
From the loan	1,200,000
Total	3,580,462

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Section IV.

ORLAND PROJECT, CALIFORNIA.

1. The board, by a committee of its members, examined this project and the reservoir sites for the proposed extensions on October 3, 1910, and held a public hearing at Orland on the evening of the same day.

2. *Location.*—The irrigable area of the Orland project lies in Glenn and Tahama Counties, and the storage reservoir in Colusa County, Cal. The town of Orland is within the project. Adequate transportation facilities are afforded by the Southern Pacific Railroad, and the Sacramento River, which is navigable in this vicinity, is also within a short distance.

3. *Description.*—The approved project includes a storage reservoir on Little Stony Creek at East Park, about 40 miles above Orland, the utilization of the bed of Stony Creek to carry water to the diversion dam at Miller Buttes and two canal and lateral systems, one on the north side to irrigate 6,000 acres and one on the south side to irrigate 8,000 acres in the vicinity of Orland.

4. The reservoir, which has a capacity of 45,600 acre-feet, is formed by a curved concrete dam of gravity section in Little Stony Creek Gorge. The maximum height of the dam is 139 feet above foundations and the length on top 250 feet. The foundations and abutments are hard conglomerate. The maximum pressure on foundations is 9.5 tons per square foot.

5. There are three gaps in the rim of the reservoir, in one of which the spillway is located. The remaining two are closed by low earth embankments. The spillway is built of concrete. It is of the arch and buttress type and has a capacity of 10,000 second-feet.

6. The diversion dam is about 9 miles above Orland, and is only partially completed. As planned, it will be a low concrete weir founded on sheet and round piling, the former driven through the gravel bed into the clay beneath. Floods bring down large quantities of heavy gravel, and the areas above those parts of the weir already built are completely filled. As this gravel will tend to choke up the canal intakes, it is probable that more or less difficulty will be encountered in maintaining a cheap and satisfactory diversion.

7. Prior to the beginning of work on this project by the Reclamation Service two private irrigation companies were diverting water to part of these lands. On the north side this was being done by the Lemon Home Water, Power, and Light Co. and on the south side by the Stony Creek Irrigation Co. The canals and ditches of both these companies were purchased by the Reclamation Service and are being enlarged, extended, and improved.

8. The north-side canal is to have a capacity of 92 second-feet and the south-side canal a capacity of 140 second-feet. The former will contain a drop of 40 feet and the latter a drop of 28 feet. At these drops 600 gross horsepower can be developed.

9. The principal structure in the distribution system thus far built is the inverted concrete siphon across Hambright Creek. Minor structures are also of concrete.

10. All of the completed structures are well built and suitable for the purpose intended.

11. *Water supply.*—Water for the project is obtained from Stony Creek, which has a drainage area above the diversion dam of 735 square miles and above the East Park reservoir of 102 square miles. The average annual run-off at the diversion dam is 750,000 acre-feet and at the reservoir 87,500 acree-feet, with a minimum at the latter point of 30,000 acre-feet in the season of 1909–10.

12. The duty of water varies from 36 inches to 42 inches, depending upon the soil. The demand also is variable during the irrigation season, nearly half of the total being required in July and August.

13. Discharge measurements have been made since 1901, and based upon average conditions during that period 36,000 acre-feet of storage would have been required to supply water for the project in accordance with the assumed demand. In this determination allowance is made for a 25 per cent loss in the creek bed and for a 20 per cent loss in the distribution system. The capacity of the reservoir exceeds the average requirement for stored water by 9,760 acre-feet, so that a supply can usually be carried over to make up deficiencies in dry years, such as 1910.

14. *Lands.*—The average elevation of the irrigable area is 225 feet above sea level, the average rainfall 17 inches, and the range of temperature from 26° F. to 120° F. The soil is a sandy loam, containing more or less gravel and silt. Experience in this valley indicates that 42 inches of water will be required on the gravelly, sandy land, amounting to 3,200 acres, and 36 inches on the remainder. Much of this land has been used in the past without irrigation for growing wheat, but in recent years the wheat crop has been very small. On the irrigated portions the principal products are alfalfa, citrus and deciduous fruits, small fruits, and vegetables. It is said that alfalfa yields six cuttings, or an average of 9 tons per acre per year, value at $7 per ton. Almonds, oranges, and grapes also yield large returns.

15. At the time this project was approved all the land under it, 14,000 acres, was in private ownership, and 8,960 acres of this amount was held by nine landowners. This land has been subdivided into 40-acre tracts and a large part of it sold. Before the project was undertaken the average price of land under it was $17 per acre. It is now about $100 an acre, not including the construction charge.

16. *Cost.*—The expenditures on the project to June 30, 1910, were $397,335, and the estimated cost to complete, subsequent to that date, is as follows:

Gravity system.

(1) East Park Reservoir	$5,000
(2) Diversion Dam	20,000
(3) North Side Canal	58,000
(4) High Line Canal	19,000
(5) Excavation, distribution system, under contracts	15,500
(6) Excavation, distribution system, to be contracted	15,500
(7) Structures for distribution system	30,000
(8) Special structures, Hambright Creek Siphon, Spillway, etc	5,000
Add 25 per cent for engineering and contingencies	42,000
Total to complete gravity system of the first unit	210,000

This makes a total cost for the gravity system of 14,000 acres $607,335, or $43.38 per acre. The estimated cost of developing power at drops in the canals to pump water for the irrigation of 3,000 acres additional is as follows:

(1) Penstock and By-Pass	$4,000
(2) Power house and equipment	10,500
(3) Transmission line	11,000
(4) Pumping plant	7,200
(5) Development of wells	10,000
(6) Distribution system	19,500
Add 25 per cent for engineering, etc	15,550
Total to develop power at drops, first unit	77,750

17. The power and pumping plants have not yet been built, and are not an essential part of the project as originally undertaken. As in the main project, the land to be irrigated by them is in private ownership. This feature of the work is from an economic standpoint desirable, but owing to the demand for reclamation funds on other projects containing public land it is not advisable. Opportunity, however, should be afforded the Water Users' Association to do this work at its own expense, if it so desires. The construction charge on this project has not yet been announced, and it will probably be somewhat less per acre than that indicated above if the power and pumping plants are installed. If the power development only is undertaken and the power sold, the construction charge will be slightly increased, but, on the other hand, the receipts from the sale of power will reduce the annual cost of operation and maintenance. In any event the construction charge is not likely to exceed $45 an acre, which, considering the productiveness of the soil, is well within what the land can bear.

18. *Extensions.*—The Orland Project, as now outlined, uses only a small part of the run-off of Stony Creek, and investigations have been made by the Reclamation Service with a view to utilizing part of the remainder. Three additional reservoirs have been considered, each of which is to constitute, with the area to be irrigated from it, an additional unit of the Orland Project. These are the Stony Gorge, Stonyford, and Briscoe Reservoirs.

19. *Stony Gorge Reservoir.*—The site of this proposed reservoir is on the main branch of Stony Creek, 3 miles above the village of Elk Creek. Surveys made in 1910 show a possible storage capacity of 104,700 acre-feet, estimated to be sufficient for 30,000 acres. Based on a rock-fill dam, with a reenforced concrete core wall, the cost is placed at $1,123,782, equivalent to $10.70 per acre-foot. The total estimated cost of the second, or Stony Gorge, unit is as follows:

(1) Cost of storage works	$1,150,000
(2) Cost of diversion works	10,000
(3) Cost of canal system, at $6 per acre	180,000
(4) Cost of distribution system, at $8 per acre	240,000
Total	1,580,000

Or $53 per acre.

20. *Stonyford Reservoir.*—This reservoir is to be located on the main branch of Stony Creek, the dam site being 4 miles above the village of Stonyford. It has a possible capacity of 50,882 acre-feet,

estimated to be sufficient for 15,000 acres. Based on an earth and rock-fill dam, the cost is placed at $667,039, equivalent to $13.10 per acre-foot. The total estimated cost of the third, or Stonyford, unit is as follows:

(1) Cost of storage works	$667,039
(2) Cost of diversion works	10,000
(3) Cost of canal system, at $6 per acre	90,000
(4) Cost of distribution system, at $8 per acre	120,000
Total	887,039

Or $59.10 per acre.

21. *Briscoe Reservoir.*—This reservoir is to be located on Briscoe Creek, a tributary of Stony Creek. The dam site is 2½ miles above its mouth. It has a possible capacity of 19,052 acre-feet, estimated to be sufficient for 5,000 acres. Based on a concrete gravity dam, the cost is placed at $282,359, equivalent to $16.30 per acre-foot. The total estimated cost of the fourth, or Briscoe, unit is as follows:

(1) Cost of storage works	$282,359
(2) Cost of diversion works	5,000
(3) Cost of canal system, at $6 per acre	30,000
(4) Cost of distribution system, at $8 per acre	40,000
Total	357,359

Or $71.50 an acre.

22. The irrigable areas under the extensions adjoin the present project and will require about the same quantity of water per acre. Fifty thousand acres would therefore require the diversion of 195,000 acre-feet. The combined storage capacity of the three proposed reservoirs is 174,634 acre-feet. Allowing the same percentage of loss in stream bed as is assumed for the first unit, only 141,000 acre-feet of this amount could have been diverted, leaving 54,000 acre-feet to be supplied directly from the river. An examination of the records of average flow of Stony Creek during the past nine years shows, however, that only 31,600 acre-feet would have been available from this source after supplying the needs of the first unit. If an additional allowance is made for surplus reservoir capacity to tide over years in which the flow is insufficient to fill them, it is evident that the proposed reservoir capacity is too small for the irrigation of 50,000 acres.

23. The costs per acre, as given above, must therefore be increased, possibly as much as 25 per cent. The land under the proposed extensions is entirely similar to that under the existing project. It is of good quality and capable of bearing a construction charge of $60 to $75 an acre. All of it is in private ownership.

24. The extensions are independent of the existing project except that the same diversion dam and main canals would probably be used, the latter being first enlarged. All of the extensions are feasible from an engineering standpoint. The first two are feasible in that the probable cost would not exceed what the land can bear. Because of high cost the feasibility of the third, or Briscoe unit, is very doubtful. These extensions do not include any public land, nor are any interstate or international features involved. These facts, together with the need of reclamation funds for the completion of other projects now under way, lead to the conclusion that none of the extensions are advisable.

25. *Summary.*—(1) The Orland project lies wholly within the State of California.

(2) It covers the irrigation of 14,000 acres, all in private ownership.

(3) The water supply is ample for this acreage.

(4) It is feasible from an engineering standpoint, and the land can bear the probable construction cost—$45 per acre.

(5) Its completion is advisable, except for the installation of the power plants, which are not an essential part of the project as originally undertaken.

(6) Opportunity should be afforded the Water Users' Association to undertake this power installation at its own expense.

(7) The extensions known as the second, third, and fourth units are feasible from an engineering standpoint, but the first two only are economically feasible. None of them are advisable.

Section V.

GRAND VALLEY PROJECT, COLORADO.

1. The board visited the Grand Valley project on September 18 and 19, inspecting the lands now under irrigation and those to be irrigated in the vicinity of Grand Junction on September 18, and the irrigated lands and proposed line of new canals in the vicinity of Palisade on the 19th.

2. On September 19 public hearings were held by the board at Palisade and at Grand Junction, at which opportunity was given those interested to express their views with regard to the prosecution of work on this project.

3. *Location.*—Grand Valley lies in the western part of Colorado about 40 miles east of the Utah line. It was formerly a part of the Ute Indian Reservation, but in 1881 the Indians were removed, and in 1882 the Denver & Rio Grande Railway extended its line into Grand Junction. These events inaugurated a rapid settlement of the valley, especially as a good water supply was available and irrigation was practicable over large areas at moderate costs. Between that time and the present seven irrigation systems have been established, covering a total of about 60,000 acres of private land, most of which has proved very productive and is now held at a high valuation. The water supply for the project and the areas proposed to be irrigated lie within the limits of the State of Colorado.

4. *Description.*—The Grand River flows for many miles in Colorado through a narrow deep canyon. At the town of Palisade the valley widens, offering large areas of land suitable for cultivation when supplied with water. On the left or south bank there are being irrigated or being prepared for irrigation about 16,200 acres of land lying in a narrow strip above and below the mouth of the Gunnison River. On the right bank the bottom has a width of two to four miles, sloping up to gravelly mesas and thence extending back to broken adobe land at the foot of Little Book Cliffs. There are on this bank 97,000 acres of irrigable land, of which 44,000 acres are now being supplied with water by private ditches, leaving 53,000

acres which are not at the present time reached by any irrigation systems. The purpose of the present project is to supply water to the 53,000 acres still unprovided for.

5. This project early attracted private enterprise, but owing to the difficult nature of the ground in which a canal for this area must necessarily lie and the distance upstream it must extend to obtain sufficient elevation for a gravity canal, this project was considered a very expensive one. It was the intention of the Reclamation Service in 1902 to commence work on this project among the first, but at the request of individuals who stated that companies would undertake the work, the project was temporarily abandoned until it was ascertained by the companies that the time was not propitious for securing capital. Request was made that the Reclamation Service resume operations on this project and accordingly a camp was established, a site for a diverting dam selected, a line of canal tentatively adopted, and other plans made. At this time the work was stopped by direction of the Secretary of the Interior, pending the settlement of the controversy over damages for rights of way through private property in the vicinity of Palisade, and no further work has been done.

6. The project, as at present outlined, is confined to the irrigation of the high land bordering the Little Book Cliffs and areas farther down the valley, all on the north side of the river. It will require a diversion dam in the canyon several miles above Palisade, and a canal partly in open cut and partly in tunnel, to conduct the water down the canyon to the main canal line bordering the cliffs. This canal line, as proposed, will have a capacity of 1,000 second-feet at its upper end.

7. *Transportation facilities.*—The main line of the Denver and Rio Grande Railroad traverses the project from end to end. No farm unit of the project is more than 10 miles from some railroad station. In addition, an electric line between Grand Junction and Fruita will be able to switch standard cars from the railroad, thus affording additional facilities.

8. *Water supply.*—The area of the watershed of the Grand River above Grand Junction is 8,644 square miles, and the average annual precipitation over this area is 15 inches. Records of the flow of the Grand River have been kept at either Grand Junction, Glenwood, or Palisade since 1897. From these records figures for the flow at Palisade have been developed. They show that in normal seasons a minimum of about 1,450 second-feet may be expected, and that in exceptionally dry years the minimum may drop to 950 second-feet in August and September. A hydrograph showing the daily flow during the average or representative years 1903 and 1906, and the years 1902, 1905, and 1910, which are years of low flow, is appended hereto. This hydrograph and the analysis of the water supply therewith were prepared by the Reclamation Service.

9. From them it appears that a sufficient water supply for this project depends, first, upon an adjudication of water rights not radically different from that assumed by the Reclamation Service; second, upon the acquisition by purchase, by contract agreement as to substitution of gravity water for pumped water, or by condemnation, of the right to use for irrigation the water now used in the development of power by the Palisades irrigation district, the Mesa

County irrigation district, and Smith Bros. (Orchard Mesa Power). These aggregate 1,091 second-feet.

10. While the assumption as to prior rights is deemed reasonable, the board believes that this project should not be undertaken until these rights have been adjudicated. As such an adjudication is now in progress, and as a decision is expected by March, 1911, there will be a delay of only a few months, the disadvantage of which will be more than offset by the advantage of knowing definitely what the prior appropriators are entitled to. The right to condemn power water for irrigation purposes has been sustained by the Colorado courts, so there is no reason to assume that the second of the two conditions can not be met.

11. *Lands.*—The land which it is proposed to irrigate amounts to 53,000 acres, as above mentioned, of which 30,070 acres are public land, 20,720 acres are private land, and 2,210 acres are homesteaded public land not subject to the reclamation act. It is thus seen that public land is approximately 60 per cent of the total. It should be added, however, that this public land fringes the cliffs or lies at the lower end of the project and includes the areas which are of lower value for cultivation because of poorer soil or greater difficulty of irrigation. It joins, however, land under cultivation which is now returning the owners large profits. Peaches are said to have yielded as high as $700 per acre per year in the vicinity of Palisade. Apples are said to have yielded as high as $600 per acre. Cantaloupes and melons are often profitably grown between trees in the orchards. Sugar beets are extensively raised. A beet-sugar factory at Grand Junction pays $5 per ton for beets delivered on the cars. Lands under cultivation in ordinary farm crops in the vicinity of Grand Junction are held at $200 to $400 per acre. Lands planted with bearing apple or pear trees sell at from $1,200 to $1,500 per acre.

12. The average elevation of the irrigable area is about 4,700 feet above sea level. The average rainfall is 8 inches and the temperature ranges from a maximum of 100° to a minimum of 15° below zero. Although nothing can be raised in the Grand Valley without irrigation, it is so protected by the bluffs that large areas now irrigated have been devoted to the raising of apples and, in the vicinity of Palisade, to peach cultivation. The gravelly land of the mesa seems well adapted to fruit raising. The lower bottom lands yield good crops of grain, sugar beets, and alfalfa, but are not so well adapted to fruit culture.

13. Under the various private irrigation systems now in operation, the building cost per acre for water has reached from $66 to $150, and from $2.50 to $6 for maintenance and operation. It seems clear that the project lands can pay back the estimated cost of this project without hardship.

14. *Cost of project.*—No construction work has been done on this project, all expenditures having been for examinations and surveys except a small expenditure made for machinery and supplies after work was authorized and prior to its suspension. The total expenditures have been $74,170.80. The total estimated cost of completion of what is known as the "low line" is $3,621,663, or about $69 per acre, which includes $200,000 for right of way through existing fruit orchards in the vicinity of Palisades. The estimated cost of a line of canal 25 feet higher up, selected to avoid injury to these orchards,

is $4,685,741, or about $89 per acre. The following table, furnished by the Reclamation Service, sets forth the comparative estimates for completion of the project on the alternative locations:

Items.	Lower line through canyon.	Higher line through canyon.
Headworks	$200,000	$200,000
Canal head gates to Palisades	944,597	1,637,546
Canal, Palisades to Little Salt, Wash	727,025	961,673
Remainder of main canal	341,239	341,239
Laterals (43,560 acres)	260,000	260,000
Power plant at Palisades	20,000	32,000
Power plant at drop		120,000
Right of way	200,090	
Engineering	180,000	190,000
Unforeseen contingencies	200,000	300,000
Administration	122,914	160,118
Pumping plants	141,065	119,065
Headquarters building and storage yard	15,000	15,000
Interest	269,823	349,100
	3,621,663	4,685,741
Unit cost, 53,000 acres	68.40	88.50

15. Although estimate of damage of $200,000 has been included, the difference between the costs of the two proposed lines is about $1,000,000. If the high line should be built this difference must be paid by the owners of lands irrigated by it. This difference will amount to nearly $20 per acre.

16. *Comments.*—No engineering problems of special difficulty present themselves in connection with this project. The diversion dam in the Grand River can readily be constructed on the selected site. The canal line down the canyon must pass through three tunnels, requiring expensive construction, but in view of the character of the material no special difficulties are expected. About 9,500 acres above the high-line canal are to be supplied by pumping. Electric power is now being sold in the valley by private companies at moderate prices, and this power is relied upon for operating the pumps. This power may be supplemented by electricity generated in drops in the main canal.

17. The principal question to be decided in connection with this project is which of the two canal lines shall be selected, the high line or the low line. Both of these lines have been surveyed and are now staked out on the ground. So far as the amount of land to be irrigated is concerned, the two lines differ very little, the higher line covering only a few acres more than the lower. The advantage of the low line is the large saving of approximately $1,000,000 which would result from its adoption. The high line was located with a view to avoiding the destruction of highly developed orchards, which would be necessary if the low line were selected. At one time an agreement was reached between the Reclamation Service and the owners of the lands through which the low-line canal is to run, fixing the amount of the damages to these lands at $154,000. This appraisal was not approved by the department, and a later estimate made by the Reclamation Service placed the total amount of damages which the United States was legally bound to pay at $75,138. A new appraisal was then made by the owners, who increased their claim to $404,188.25. An estimate transmitted to the board by the owners on October 24,

1910, again increased the estimate of the damages to $540,335. The construction of the lower line involves the occupation of about 150 acres of orchard, running in value from $350 to $3,500; but the right of way is already vested in the United States in accordance with the stipulated conditions under which the land was opened to homestead entry. Therefore no payment can be legally demanded for the land itself.

18. From these figures it appears that to avoid damages to the highly developed orchard lands the land which it is proposed to irrigate will have to pay an additional construction cost exceeding the highest estimate for the damages by about $660,000, or over $12 per acre for the 53,000 acres in the project. The board, therefore, is of the opinion that the low line should be selected as the location for the canal. The estimates of the owners as to the extent of damages to be incurred appear to be high, and if negotiations do not result in an agreement for a considerably smaller amount, then condemnation proceedings should be resorted to for the determination of the damages.

19. *Summary.*—(1) The project is feasible from an engineering and an economic standpoint.

(2) It lies within the limits of a single State—Colorado.

(3) It contains 53,000 acres, of which 60 per cent is public land subject to the reclamation act.

(4) The water supply will be sufficient for this project if the adjudication of water rights when made is not radically different from what is assumed by the Reclamation Service and after the water now used by certain private owners for power has been acquired for irrigation by agreement or condemnation. No extensive work should be done until the water supply is thus assured.

(5) The estimated cost of completion of the high line is $4,685,741, and of the low line is $3,621,663, of which $74,170.80 has been expended mainly in surveys and plans.

(6) The lower-line canal should be adopted, and if a reasonable estimate of damages to permit this can not be obtained by agreement then condemnation proceedings should be instituted.

(7) The productiveness of the land makes it probable that the construction cost of about $69 can be readily borne, or even $89, if the high line should be adopted.

(8) The prosecution of this project is recommended conditional on an adjudication of water rights not materially different from that assumed by the Reclamation Service.

(9) Subject to the above condition the following allotments are recommended for the four years 1911–1914, inclusive:

From the fund	$500,000
From the loan	1,000,000
Total	1,500,000

Section VI.

UNCOMPAHGRE PROJECT, COLORADO.

1. This project, including the proposed reservoir site at Taylor Park, was inspected by the board as a whole, or by commitees, between September 20 and September 23. Public hearings were held at Montrose on September 20 and at Delta on September 22.

2. *Location.*—The Uncompahgre Valley lies in western Colorado near the mouth of the Uncompahgre River, which is a branch of the Gunnison River. This latter flows into the Grand. The entire project, including sources of the water supply, lie within the State of Colorado; the lands are located in Montrose and Delta counties.

3. *Early irrigation in valley.*—The Uncompahgre Valley was first settled about 1882, and plans were made by private parties for irrigating about 100,000 acres from the Uncompahgre River. Ditches were constructed, but it was found that there was not enough water, and in 1904 only 30,000 acres were under cultivation, and these with insufficient water. About the year 1900 the State Legislature of Colorado appropriated $25,000 to bring water by tunnel from the Gunnison River into the Uncompahgre Valley. The tunnel was started, but the appropriation being exhausted the uncompleted work was turned over to the Reclamation Service. The location of the tunnel was found unsuitable, and it was not used.

4. *Description.*—The project, as undertaken by the Reclamation Service, provides for irrigating land lying in the Uncompahgre Valley with the water of the Uncompahgre River, supplemented by the water brought from Gunnison River. In case this does not suffice, a storage reservoir at Taylor Park on the Taylor River has been proposed. No suitable reservoir site has been found on the Uncompahgre River.

5. The water from the Gunnison River is diverted into the Gunnison Tunnel. On leaving the tunnel it flows through the South Canal for eleven miles and is dropped into the Uncompahgre River. By laterals from the South Canal 13,600 acres will be irrigated. From the Uncompahgre River, the water of that river, supplemented by that from the Gunnison, will be diverted at different points into six canal systems. The upper one, called the West Canal, irrigating 7,200 acres, is yet to be constructed. The Montrose and Delta Canal system, covering 33,600 acres, and the Loutsenheizer system, covering 24,600 acres, have been acquired by the Reclamation Service and are being enlarged and extended. Negotiations are in progress to acquire the Selig system, 9,000 acres; the Ironstone system, 26,000 acres, and the Garnet system, 4,000 acres. In addition, a new system, called the East Canal system, covering 22,000 acres, and connected with the Loutsenheizer Canal, is to be built.

6. Negotiations are also in progress to acquire a few additional minor canals belonging to private parties. These canals will be abandoned and the land irrigated by one of the above-mentioned systems.

7. The Gunnison Tunnel is 6 miles long and has a capacity of 1,300 cubic feet per second. It is completed excepting the diverting weir on the Gunnison River and the lining of the tunnel for 13,000 feet. It has been carrying water during the past season. The South

Canal is practically completed. Final agreements as to the acquisition by the United States of the remaining private canal systems have not yet been completed. It seems probable that these can be satisfactorily arranged, as the sentiments expressed at the public hearings were strongly in favor of the acquisition by the United States of all the canal systems. The secretary of the Water Users' Association stated that all private land in the project, except about 5,000 acres, had subscribed for water, and, while the exact figures were not verified, it is believed that less than that acreage will remain permanently out of the project.

8. *Water.*—A discussion of the water supply is appended. There were numerous previous water rights aggregating 40 different ditches, of which 10 were of considerable size. On the assumption of the acquisition by the United States of the ditches within the project limits with their water rights, and making allowance for other rights, it appears that there will usually be sufficient water on the basis of 2½ to 3 acre-feet at the farm when the Gunnison Tunnel is runnnig full—that is, about 1,300 second-feet. There will be years when the supply will be scant, and to insure what is needed a storage reservoir for Gunnison River water will, it is thought, prove necessary. The rainfall on watershed is from 7 to 20 inches.

9. *Land.*—The total irrigable area under the project is 140,000 acres, of which 106,000 are in private ownership and 34,000 acres public land, subject to the reclamation act. The larger part of the land withdrawn subject to the reclamation act has been entered for settlement. It is possible that these areas may be somewhat modified, as all of the private land has not yet been signed up for water. Most of the public land is generally on the higher benches and will, therefore, be the last to be brought under irrigation.

10. The land irrigated this year has been about 40,000 acres, practically all under cultivation before. Water was sold at a fixed price per second-foot. While the full quantity of water desired was not supplied this year, it is stated that, due to the extra water from the Gunnison River, an additional crop of alfalfa and larger crops of fruits and vegetables were obtained. No crops can be raised without irrigation.

11. Of the 140,000 acres under the project, about 60,000 acres are of red disintegrated sandstone, a sandy soil particularly adapted to the raising of fruits and vegetables; 80,000 acres of adobe, or clay loam, which gives good crops of alfalfa, grain, sugar beets, and other farm products. Alfalfa is the main crop. Potatoes and onions have been raised with marked success. It is claimed that the clay soil, after several years of cultivation, develops into good fruit land. There is a considerable portion of waste land. About 40,000 non-irrigable acres, of which 20,000 acres are private, are included within the limits of the project, but not counted as irrigable area.

12. The bottom land shows evidences of "swamping" in a number of places, some of which have been reclaimed by the construction of drainage ditches, and it is thought that all of it can be reclaimed. The land lying on the benches is not so much subject to "swamping," but it is probable that some drainage ditches will be required. An estimate of $210,000 is proposed by the Reclamation Service for drainage. There are not many indications of alkali.

13. Before the inauguration of the project lands without water were worth from $2 to $25 per acre. Lands under irrigation, used for alfalfa, grain, etc., were worth from $50 to $150 per acre. Prices are now $40 for land on the outskirts of the project and up to $800 for fruit-bearing orchards.

14. The Denver & Rio Grande Railroad runs through the project, so that there is good railroad transportation.

15. *Engineering structures.*—The Gunnison Tunnel is about 6 miles long, and cost about $100 per running foot. This is rather a high price, due to its great length, the difficulties under which is was constructed, the failure of the contractors and the necessity of taking it up by force account, the flooding at different intervals, the large amount of gas encountered, etc.

16. The South, or main supply, Canal is for a considerable portion of its length lined with concrete, and at many points the earth thrust has forced the lining out of place. This is not considered serious. The drops in this canal are somewhat more costly than would seem to be necessary, but apparently fulfill their purpose. There is some leakage, but it is expected that this will be stopped by the gradual deposit of silt.

17. No work has been done at the Taylor Park reservoir site, and no borings made, so that the cost of the dam is difficult to determine, and the estimate of $2,000,000 must be considered only as an approximation. The storage capacity is estimated at 105,000 acre-feet. An examination indicates that a sufficiently good reservoir site exists at this point, but that further investigations are desirable. As a whole the engineering features seem to be well studied out and carefully executed, economy being observed as far as conditions permitted. The proposed plan for completion appears satisfactory.

18. *Cost.*—The total allotments to date aggregate $4,455,000, of which about $3,000,000 was applied to the construction of the Gunnison Tunnel and the remainder to the purchase and enlargement of private canals, construction of South Canal, and for minor features. The cost of completion is estimated at $4,500,000, or an estimated total cost of $9,000,000, including $2,000,000 for the Taylor Park Storage Reservoir. The detailed estimate for completion is as follows:

1. Gunnison River weir	$40,000
2. Gunnison Tunnel lining	305,000
3. Betterments, South Canal	50,000
4. South Canal lateral system	25,000
5. Betterments and lateral system, Montrose and Delta Canal	135,000
6. Enlargements and lateral system, Ironstone Canal	260,000
7. Cedar Creek lateral (part of South Canal system)	25,000
8. West Canal and lateral system	350,000
9. Enlargement and lateral system, Loutsenheizer Canal	325,000
10. Enlargement and lateral system, Selig Canal	45,000
11. East Canal and lateral system	350,000
12. Betterments, Garnet Canal	10,000
13. Purchase of existing old rights and canals	225,000
14. Taylor Park Reservoir	2,000,000
15. Contingencies	[1] 400,000
	4,545,000

[1] This item covers possible drainage systems, extensive renewals, etc.

19. Independently of the storage system, the estimated final cost would be about $7,000,000, which for 140,000 acres would give a building charge of about $50 per acre. It is desirable, however, to include in the construction cost the reservoir, which is believed to be necessary. Due to uncertainties in the estimates, and possible increases in the unit costs, as well as to the uncertainty as to the amount of land which can be included, it would seem safe to estimate on a construction cost per acre of at least $70.

20. The fruit land could stand this charge of $70 per acre, and probably all of the irrigable areas could do so in time. The cost of operation, when completed, is estimated at $0.75 to $1. It was the generally expressed opinion of the landowners that the land could bear these costs, except that some homesteaders felt that the burden would be heavy. This would seem, however, to be near the limit of construction cost that the land can bear.

21. *Returns to reclamation fund.*—No returns have been received up to the present time except rent for water. Due to the large proportion of land now under cultivation and the probability of early settlement of public land when thrown open, practically all land should begin to pay construction costs as soon as the different canals and laterals are completed.

22. *Summary.*—(1) The project is feasible from an engineering and economic standpoint.

(2) All the project, including the water supply, lies within the State of Colorado.

(3) The total irrigable area is 106,000 acres, of which about 32 per cent is public land subject to the reclamation act.

(4) On the assumption of the unification of private water rights and their acquisition by the United States, the water supply will be sufficient, though a storage reservoir is probably necessary.

(5) The estimated expenditure, including storage reservoir, is $9,000,000, of which $4,455,000 have been allotted to December 31, 1910.

(6) The land can bear the construction cost estimated not to exceed $70 per acre.

(7) The board believes the project to be worthy. All matters connected with the acquisition of private canals should be settled as early as possible, and definite and binding agreements should be made as to repayment of building charges before large additional expenditures are authorized.

(8) The following allotments are recommended for the four years, 1911–1914, inclusive:

From the fund	$2,045,000
From the loan	1,500,000
Total	3,545,000

Section VII.

MINIDOKA PROJECT, IDAHO.

1. *Inspection.*—The board inspected this project, except the storage dam at Jackson Lake, Wyo., on September 10 and 11, including in the inspection a private project on the south side of the river at Twin

Falls, Idaho. From September 12 to 14, inclusive, was spent by a committee of three members of the board in going to, inspecting, and returning from the reservoir site at Jackson Lake. A public hearing was held on September 10 at Burley, Idaho.

2. *Location.*—The project is located in Lincoln and Cassia Counties, Idaho, and lies on both sides of the Snake River. The Minidoka & Southern Railroad runs through the project, leaving the main line at Minidoka, with terminus at Buhl.

3. *Description.*—The lands are to be irrigated partly by gravity and partly by pumping, of which, under the latter method, there are three units, all on the south side of the river. The main features comprise a storage and diversion dam 6 miles from Minidoka, Idaho, called the Minidoka Dam, the storage lake being called Lake Walcott, a generating power plant at Minidoka Dam, distributing canals, three pumping plants for the pumping units, and a storage dam at Jackson Lake, Wyo., about 275 miles above the Minidoka Dam. The essential features of the dam and power plant at Minidoka Dam and of the pumping plants are given in Appendix 1 to this section.

4. The distribution system takes its origin at Lake Walcott, two main canals leading from it, one on each side of the river. The north-side main canal extends westwardly from the dam and lake a distance of 13 miles, where it divides into two systems, one covering the area south of the railroad and the other the area north. This main canal has at its origin a capacity of 1,400 second-feet and serves the 68,500 acres of the north-side gravity system. This distribution system is almost completed. The south-side main canal, with a capacity of 850 second-feet, pursues a southwesterly course for 13 miles, minor laterals being taken out at intervals, serving 7,500 acres by gravity. At the end of this canal is placed the pumping works for the first pumping unit. These pumps lift 500 second-feet to the main canal for this unit, which carries 110 second-feet in a westerly course 18 miles, irrigating 10,500 acres of land. Just beyond the first pumping unit is placed the second unit, lifting 375 second-feet to the main canal of this unit, which in turn extends westerly 22 miles, carrying 160 second-feet and irrigates 16,000 acres. A short distance along the main canal of the second lift is located the third pumping unit, lifting 200 second-feet to the main canal of this unit. This canal has a full length of 25 miles and irrigates 22,000 acres. The lift at each plant is 30 feet. On the north side of the river only the main laterals are constructed by the United States, the construction of the farm laterals being left to the landowners. On the south side, however, owing to the more difficult nature of the ground, the laterals are carried to each farm unit.

5. During the winter months the pumping plants do not require power, therefore arrangements have been made to dispose of the electrical power to the towns on the project. Transmission lines, substations, etc., are being put in and delivery of power is expected to begin this fall. Additional charge is made for power and heat during June, July, and August. The returns from this sale of power after reimbursement of cost of special installations therefor, and their operation and maintenance will go to reduce the operation and maintenance charges.

6. There are three Government town sites on this project—Acequia, Rupert, and Hayward—on the north side of the river. There is a private town site—Burley—on the south side.

7. *Water supply.*—The water supply for this project is taken from the Snake River, having a watershed above the diversion dam of 22,000 square miles. The average elevation of the watershed is 6,000 feet above sea level, with an estimated average annual rainfall of about 21 inches. The duty of water on this project is taken at 3 acre-feet per annum, measured on the land. The rainfall on the irrigable area averages 14 inches per annum, but on account of the character of the soil this amount is too small to allow profitable cultivation without irrigation.

8. Allowing for prior filings, the natural flow of the river is not sufficient to supply the needs of the project for irrigation during the low water. This deficiency is supplied by storage at Lake Walcott and Jackson Lake. At Lake Walcott storage for about 52,000 acre-feet is now provided, and at Jackson Lake works are now in process of construction which will provide storage for 380,000 acre-feet, or a total of 432,000 acre-feet. The flood flow of the river occurs during the earlier half of the irrigation season, and therefore the storage will not be drawn upon until the early part of July nor required after the middle of October. It would appear, as shown in Appendix 2 to this section, that the storage provided is ample to supply the needs of this project for the lands involved. As the low-water flow of the Snake River up to 3,400 second-feet must pass over the Minidoka Dam, supplying the Twin Falls projects farther down the river, it is evident that the power rights at Minidoka Dam, for which filing was made January 30, 1909, for 2,500 second-feet, are amply protected.

9. *Lands.*—The average elevation of the irrigable area is 4,200 feet above sea level and the average yearly rainfall 14 inches. Dry farming is not successful. The total amount of land under this project is 124,500 acres, of which 101,600 are public, 19,800 State, and 3,100 private. Under the gravity system are 76,000 acres, of which 68,500 are on the north side and 7,500 on the south side. Under the pumping system are included three lifts covering 48,500 acres on the south side. A fourth pumping unit, also lifting 30 feet, comprising 5,000 to 7,000 acres, was considered. If the lift in this unit is reduced to 15 feet, 2,500 acres could be covered. The lands in this project are shown on the accompanying map. Owing to the practicability of large extensions to the power facilities at Minidoka Dam, it is possible to irrigate by pumping about 100,000 acres in addition to the areas now included in the project. This would involve, of course, the construction of other reservoirs. The size of the farm unit is 40 acres near town sites and 80 acres farther out. The private-land unit is 160 acres. Of the State lands under the pumping unit about 10,000 acres have been sold in 40-acre tracts, but the State is making no effort to sell the remainder of its lands. It is suggested that an effort be made to induce the State to dispose of these lands, as otherwise the water rights of the United States may be adversely affected through lack of beneficial use. The value of the lands is reported to be $100 per acre under irrigation, and at the public hearing it was stated that a construction charge of $50 per acre could be easily carried. The soil is clay, disintegrated lava,

sandy loam, and loose sandy soil underlaid with lava rock at depths varying from 1 to 100 feet. The crops are alfalfa, grains, corn, vegetables, some fruits, with a probability that sugar beets will be found a profitable crop. A demonstration farm is maintained by the Reclamation Service on an unsold portion of the town site of Heyburn.

10. On the south side the lands slope well toward the river and possibly will not need drainage for some years. On the north side the land is undulating and disposal of waste water is more difficult. A drainage ditch has been started, which will pass through the entire tract on this side if found necessary. Underlying these lands are found porous beds of lava and gravel, and drainage of some of the low basins has been tried by sinking drainage wells to depths of 200 feet into these porous beds. These have been fairly successful where tried, but are as yet only an experiment.

11. *Cost.*—The cost of the project to June 30, 1910, was $3,330,770 for irrigation and $42,955 for drainage. The estimated subsequent expenditures are as follows:

General expense	$47,550
Diversion dam and headworks	22,610
Main south side canal	88,140
Power station	67,330
Pumping stations	193,750
Transmission lines	17,620
Telephone lines	4,600
South side pumping and distribution system	44,720
Office buildings and quarters	10,700
Small extensions and miscellaneous	50,580
Commercial light and power	14,280
Lake Walcott storage	21,000
Equipment and material in stores	89,650
Jackson Lake storage	281,000
Total	774,230
Waste water or drainage system	357,045

The estimated total cost is, therefore, $4,105,000 for irrigation and $400,000 for drainage.

12. The building charge for lands under the pumping system has not yet been announced, but will probably be in the neighborhood of $50 per acre. It is proposed by the Reclamation Service to fix the charge so that the total expenditures on the project will be returned to the United States. The building charge for the gravity system was first set at $22 per acre. This was found to be too low, and in order to make up a part of the deficit thus caused, on March 30, 1909, the Secretary of the Interior announced that for the gravity unit on all public lands (including relinquishments) thereafter entered and on all unsold State lands the building charge would be $30 per acre. Data furnished do not enable a precise determination of the amount of land that is affected by this advance, but it appears that approximately 70,000 acres will pay $22 and 6,000 acres $30. With these figures and the estimated costs above given, it is evident that the charge (not yet announced) to the lands under the pumping units must be over $49 in order to return to the United States the total expenditures on the project. If the drainage system, estimated to cost $400,000, be included in the construction charge for the 68,500

acres on the north side served by it, $6 per acre should be added to the charge for those lands. It would, of course, not be proper to add any of the cost of this drainage to the construction charges for the pumping units or to those for the south side gravity unit. It must be collected from the 68,500 acres benefited, either as a supplemental construction charge or in the form of increased operation and maintenance charge on them. If divided over 10 years, this extra cost would be in either case about 60 cents per acre per annum.

13. During the season 1909 about 30,000 acres in the gravity unit were actually irrigated and 3,600 acres in the pumping units. For 1910 the corresponding figures are 48,000 and 4,000 acres. The charge for operation and maintenance for 1910 is $0.60 and $1.50 per acre for the gravity and pump lands, respectively. The total estimated cost of operation and maintenance to December 31, 1910, is placed by the project engineer at $132,105 (assuming the experimental farm to be self-supporting), and the accruals to the same date are estimated at $130,600. In ensuing years there should be no deficit in operation and maintenance. At the public hearing a request was made for an extension of the project to include a fourth pumping unit. This unit had been considered in the earlier studies of the project, and lands under it had been reserved under the reclamation act. Settlers have taken up lands under the act and are naturally anxious to have the works extended to cover them, but on account of the large construction cost the Reclamation Service decided that it would be impracticable to do so. The correctness of this decision is concurred in. All of these lands should be released, if this has not already been done.

14. The construction of the Minidoka Dam necessitated the abandonment of the water wheels used in irrigation of the Howell ranch, just below the dam site on the south side of the river. A contract has been made with the owner by which the Reclamation Service agrees to furnish water for 156 acres for $50 rental price yearly.

15. *Comments.*—The engineering work on this project seems to have been well done. At Jackson Lake a temporary crib dam was constructed in 1906–7 to supply storage, pending design of permanent works and decision as to whether the offer of private parties to combine in the construction of large storage dams to serve both their own needs and those of the Government should be accepted. This dam was washed out in 1909, and immediate replacement was necessary. The design of the new structure, providing for the needs of the Government only, is well adapted to the site. The method of changing the Minidoka Dam from a plain diversion dam to include storage is somewhat unusual in design, but appears to be successful, the only thought being that in the form constructed it may be subject to damage from ice or drift. The construction of the power house over the part of the dam containing the sluice gates, which were put in for the purpose of draining the reservoir, renders it impossible to use these sluice gates without removing the draft tubes in front of the sluices which it is desired to use.

16. *Summary.*—(1) The Minidoka project is feasible from an engineering and economic point of view.

(2) This project is interstate in character in that, while the irrigable area lies in Idaho, a large part of the water for it is stored in another State, Wyoming.

(3) Of the total area of 124,500 acres in the project, 101,600 acres, or 83.2 per cent, are public, subject to the reclamation act.

(4) The water supply is ample.

(5) The total estimated expenditures are $4,505,000, of which $3,373,725 had been expended to June 30, 1910.

(6) The land will bear the construction charges. In the case of the pumping units, these charges approximate very closely the sum which the land can at present bear, but future increases in value and better knowledge of irrigation methods may, perhaps, render this charge more easily borne. For the gravity unit, the construction charge has been announced at $22 per acre for 70,000 acres, more or less, and at $30 per acre for 6,000 acres, more or less. For the pumping units the charge, not yet announced, is estimated at $50, approximately.

(7) This project should be completed as rapidly as funds will permit.

(8) None of the extensions should be undertaken until the project as now defined has been completed.

(9) The following allotment is recommended for the four years 1911–1914, inclusive:

From the fund---------- $528,000

Section VIII.

BOISE PROJECT, IDAHO.

1. The board visited this project by a committee of three members on September 8 and 9, 1910, inspecting on those dates the principal features. On September 8 a public meeting was held at Nampa, Idaho, and on September 9 one was held at Caldwell, at both of which great interest was shown in the early completion of the project. A committee of the board inspected the site for the proposed storage dam on the headwaters of the Boise River on September 25, 1910.

2. *Location.*—The project is located in the southwestern part of Idaho in the valleys of the Snake and Boise Rivers, in Ada and Canyon Counties. Its limits are wholly within the State of Idaho. The project is served by the Oregon Short Line, the Idaho Northern Railroad, and by the Boise Valley and the Boise and Interurban electric lines. The principal towns are Boise, Nampa, and Caldwell.

3. *Description.*—The original Payette-Boise project included an area of 402,700 acres and was divided into four subdivisions, as follows:

First. The Payette division, comprising lands in the Payette Valley and part of the Boise Valley, the total area being 72,000 acres, of which 60,000 were desert and 12,000 under cultivation.

Second. The North Side Boise unit, comprising lands on the north side of the Boise River under Farmers Union Canal, the total area being 33,000 acres, of which 25,000 acres were desert and 8,000 cultivated.

Third. The South Side Boise unit, comprising 272,000 acres, of which 109,000 acres were already irrigated or provided with canals of sufficient capacity therefor.

Fourth. The Succor Creek division, comprising lands on the south side of Snake River near the Idaho-Oregon State line, the total area being 25,700 acres, of which 10,000 acres were to be served by reservoirs on Succor Creek and 15,700 by pumping from the Snake River, the power for which was to be obtained from the proposed Payette Canal.

4. Owing to the lack of funds and legal complications, and in response to petition of settlers in the North Side and Payette subdivisions, three of these subdivisions have been abandoned for the present, as well as certain portions of the third subdivision aggregating 29,000 acres. Forty thousand acres of land, reserved for the Payette division, have been restored to entry, and settlers are proposing to take up this work by private enterprise.

5. The project as now defined lies within the third subdivision above enumerated, and comprises a total of 243,000 acres, of which 164,000 are new lands and 79,000 are old lands already under irrigation from private ditches. The relationship existing between the owners of these canals and the Government will be described later. A map of the locality showing the lands to be irrigated is herewith appended.

6. The main works are: The diversion dam in the Boise River, the Deer Flat Reservoir, the distributing system, and the proposed storage dam on the headwaters of the Boise River. The diversion dam in the Boise River lies about 8 miles above the city of Boise, and from it leads a small canal on the north side supplying a small area on that side, and a main canal on the south side with a capacity of about 2,500 second-feet. This latter canal extends in a southwesterly direction and empties into Indian Creek. The waters flow down Indian Creek for a distance of 9 miles, where they are again diverted by means of a dam and headgates to the second stretch of the main canal 8 miles in length, terminating in the Deer Flat Reservoir, the available capacity of which is 170,000 acre-feet. This main canal was acquired from the New York Canal Co., and besides supplying the reservoir irrigates the company lands and certain new lands. To serve these purposes suitable enlargement is now being made. The reservoir is formed in a natural depression by two embankments containing about 1,000,000 cubic yards each. From it are led three distributing canals to various parts of the project. A certain amount of storage will be necessary on the headwaters of the Boise River to fully irrigate the area comprised in this project. A brief description of the Deer Flat embankments will be found in the appendices to this section, together with the report of the committee of the board which inspected the storage site on the Boise River.

7. *Water supply.*—The source of the water supply for this project is the Boise River, the watershed of which, above the diversion dam, is approximately 2,610 square miles, with an average rainfall of about 25 inches. The maximum run-off of the Boise River is about 3,000,000 acre-feet, the mean about 2,000,000 acre-feet, and the minimum 1,000,000 acre-feet. The flood season covers generally the months of March, April, May, June, and a portion of July, and during these months there is usually ample water for all purposes without storage. After the flood season is past the normal flow of the river must be supplemented by storage. The duty of water is taken at 2½ acre-feet per acre per annum measured on the land. Within the project are

two private irrigation districts, as well as the land owned by the New York Canal Co. The districts consist of the Pioneer irrigation district, controlling the Phyllis and Caldwell Canals, covering 36,000 acres, all irrigated, and the Nampa and Meridian district, controlling the Ridenbaugh Canal, covering 25,000 acres, irrigated, and 30,000 acres of unirrigated land. The latter will be irrigated through the district distributing system by water furnished by the Government. The New York Canal Co. owns 18,000 acres under irrigation lying under the main canal of the project. All of these lands have adequate flood-water rights, and the total low-water flow of the river has been appropriated many times over. The adjudication of water rights in the valley has been before the courts and the total prior appropriation was determined, amounting to 2,754.8 second-feet. The Reclamation Service regarded this adjudication as excessive in amount and appealed to the superior court. The case has been remanded for retrial and a temporary decree handed down fixing the private appropriations at a total of 60 per cent of this amount. The final adjudication of these rights is important, inasmuch as upon it will depend the amount of storage necessary on the headwaters of the Boise River for a given amount of land, or will determine the total acreage that can be irrigated under the Government project with the storage now proposed.

8. The United States has acquired rights under Idaho State laws to a flow of 1,647 second-feet from the Boise River for the use of the main south side canal and has applied for 3,553 second-feet additional water for use in the main south side canal, Deer Flat Reservoir, and Boise River Reservoir when constructed.

9. In making a study of the water supply the following assumptions are made by the project engineer, viz: That there is a 10 per cent loss in filling Deer Flat Reservoir; that there is a 30 per cent loss in the lateral system above the reservoir and a 30 per cent loss in the distributing system below the reservoir; that seepage losses are 0.5 acre-foot per month for each acre of submerged area in the Deer Flat Reservoir; that evaporation losses equal 5.33 acre-feet for the entire year; and that the rainfall is not considered. Based on these assumptions and on the measured discharges of the river, there is available for storage on the headwaters not less than 200,000 acre-feet. The amount required to be stored in this reservoir for the project for the years given would have been as shown in the following table:

1895	184,000
1898	151,000
1902	167,000
1903	144,000
1904	100,000
1905	226,000
1906	124,000
1907	97,000
1908	86,000
1909	40,000

The mean of these amounts is 131,000 acre-feet. If a storage of 150,000 acre-feet is provided, sufficient water would be available for the project seven years out of the ten, and for the remaining three years in only one, 1905, would the deficiency have been serious, and even for that year the lack of water would not have been sufficient to have prevented fair crops being grown. On account of the high cost

of this storage, reservoir capacity beyond this amount does not seem warranted.

10. *Lands.*—The average elevation of the irrigable area is 2,500 feet above sea level, and the average rainfall is about 13 inches, an amount too small to permit successful dry farming in this locality. At the present time the distribution system is capable of delivering water to 187,338 acres. Of these, 108,338 acres, comprising 1,237 farm units, are new land. There remain 652 farm units, comprising an area of 55,806 acres, for which the distribution system is not completed. During the present season 30,000 acres were irrigated, of which 18,000 acres are under the New York Canal, receiving water under agreement described below, and 12,000 acres were new lands. Of the 243,000 acres, 85,820 are entered subject to the reclamation act, 30,059 are State lands, and 127,130 are private lands.

11. With regard to the lands under the old canals, the status is as follows:

(*a*) An agreement was made with the New York Canal Co., dated March 3, 1906, by which the United States is to carry in its main canal, which was the main canal of the New York Canal Co., 277.86 second-feet of water, subject to the priority determined by the courts for the stockholders of this company, as a consideration for the use of the canal and its right of way. This water is to irrigate the lands originally under the New York Canal and they are to pay an equitable portion of the annual cost of operation and maintenance of this project, but otherwise receive their water without cost, so far as the United States is concerned.

(*b*) An agreement was also entered into with the Idaho-Iowa Lateral & Reservoir Co., dated March 3, 1906, based on the carrying rights held by their company in the New York Canal, in consideration for which the Reclamation Service is to fill annually from the unregulated flow of the Boise River certain reservoirs, total capacity not to exceed 10,000 acre-feet, with specific allowances for seepage and evaporation losses. The company is to pay its proportionate part annually of the cost of delivering water to the entire reservoir system along the main canal.

(*c*) Another agreement, with the Nampa-Meridian Irrigation district, dated April 1, 1909, provides for the enlargement and construction of irrigation canals in that district by the Reclamation Service, for the delivery of the water into the canals of the district by the Reclamation Service, and the distribution by the district of this water to the Government users in the district. The water users are to pay the Reclamation Service for the construction and the general operation and maintenance charges and the Reclamation Service is to pay the district for its services in delivering water to the lands.

12. Members of the Riverside, Pioneer, and Nampa-Meridian districts subscribed to stock of the Payette-Boise Water Users' Association under contracts allowing a credit to them of $14 per acre, or a proportional part thereof depending on the water rights, as the value of the works and water rights of the subscribers, who were in due course to be supplied with full water from the project by the United States. These credits and the method of proportioning them were accepted by the department and appropriate provision is to be made in the public notice opening these portions of the project. Dur-

ing the present year the Riverside Irrigation was released from its contract at its own request. Should the present arrangement be carried out with the other two districts, it is estimated by the project engineer that 30,000 acre-feet additional of stored water will be needed. Owing to the difficulty and high cost of obtaining this additional storage, it would be advisable to terminate the contracts of the Pioneer and Nampa-Meridian districts by mutual consent, if practicable. For these reasons neither the lands concerned nor the water supply for them have been further discussed in this report.

13. *Cost.*—The expenditures on this project to June 30, 1910, have been $3,404,327.18. The estimated additional cost to complete is as follows:

General expense	$356,000.00
Examinations and reconnoissances	7,000.00
Diversion dam	8,000.00
Main south side canal	482,115.00
Distribution system from main canal	675,414.93
Storage, Deer Flat Reservoir	107,000.00
Distribution system, Deer Flat Reservoir	382,619.00
Storage on Boise River	5,200,000.00
Penitentiary Canal	1,960.00
Irrigable lands	13,000.00
Operation and maintenance	200,000.00
Telephone system	15,000.00
Total	7,448,108.93

The total estimated cost of completion is therefore $10,852,435.11. This estimate contains an item for storage on the headwaters of the Boise River which is approximate only, as full data regarding it have not yet been obtained. Field parties are now at work investigating various sites for this storage. From the information already gathered it is evident that this work will be costly per acre-foot of storage. It may also be remarked that the storage required can not yet be definitely determined as the final adjudication of the water rights on the Boise River has not yet been made.

14. If we assume that this total cost is divided among 164,000 acres of land, the construction cost per acre will be about $66. This expenditure will be divided approximately equally between the Boise River storage and the remainder of the project. As this storage contemplates a capacity of 150,000 acre-feet, it is seen that it will cost about $35 or more per acre-foot. This high cost can not be avoided, because of the unfavorable condition for storage existing on the headwaters of the Boise River.

15. No amount has as yet been fixed by the Reclamation Service for the construction charge, but from facts developed at the hearings and from information received by the board during its inspection, the board is of the opinion that the lands will be able to bear the construction charge that may result from the completion of the project with reasonable economy. Lands in the project without water are selling at from $50 to $75 per acre. Lands under cultivation with fairly good water rights under the old canals are selling at from $150 to $250, and even as high as $500 per acre. The soil is fertile, easily worked, and the climate is well adapted to fruit raising, as well as to the growing of grains and alfalfa. Large crops are the rule, with sufficient water for irrigation. Owing to the fact that

flood water irrigation under a rental basis is being taken up by the farmers as fast as the distribution system is completed, these farmers are raising small crops and will have no difficulty, with reasonable foresight and care, in meeting the payments as they fall due.

16. As the construction cost has not yet been announced, there should be no loss to the United States, as it can be fixed so as to return to the fund the total cost. At present the operation and maintenance charges are partially met by a rental charge of $0.75 per acre to lands receiving water through the partially completed system, the receipts for 1909 being $12,708.71 and the expenditures $40,327.52. The deficit is charged to construction account and an item of $200,000 is included in the estimate to cover such deficit until the project becomes self-supporting.

17. *Comments.*—Generally speaking, it is believed that the works have been constructed with due regard to sound engineering principles. There is no serious engineering difficulty to be overcome, and the project is feasible. While neither of the Deer Flat embankments has as yet been subjected to any very great head of water, some leakage is shown through or under the upper one, and it is believed that they should both be watched with care as the water rises in order to determine whether the leakage increases to any alarming extent. Attention is also invited to the probability of leakage through the bottom of the reservoir. The cost of the proposed storage on the upper Boise will be high, and the board believes that it will be wise to defer the construction of this reservoir until the water rights have been finally adjudicated and until the quantity of water necessary to be stored in this reservoir is determined with more exactness.

18. *Summary.*—(1) The Payette-Boise project is feasible from an engineering and an economic standpoint.

(2) It lies wholly within the limits of the State of Idaho.

(3) Of these lands, amounting to 243,000 acres, 35 per cent is public land subject to the reclamation act.

(4) The water supply is sufficient in all except very dry years, during which there may be some lack of water.

(5) The total estimated cost is $10,852,435.11, of which $3,404,327.18 had been expended to June 30, 1910.

(6) The lands can bear the construction charges, approximately estimated at $66 per acre.

(7) The project is worthy of completion at such rate as funds can be allotted and the work economically performed.

(8) The contracts now existing for supplying water to members of the Nampa-Meridian and of the Pioneer irrigation districts should be terminated by mutual consent, if practicable.

(9) The following allotments are recommended for the four years, 1911–1914, inclusive:

From the fund	$4,585,435
From the loan	2,000,000
Total	6,585,435

Section IX.

GARDEN CITY PROJECT, KANSAS.

1. The board visited this project on October 19, 1910, inspecting the power plant, one of the pumping units, the concrete conduit, and a portion of the irrigable lands. A public meeting was held at Garden City on the same day, at which the directors of the Finney County Water Users' Association were present.

2. *Location.*—This project is located on the Arkansas River, in Finney and Kearney Counties, in the western part of Kansas. Transportation facilities are furnished by the Santa Fe Railway, and there is also a short railroad connecting Garden City, the principal town in the project, with Scott City, Kans.

3. *Description.*—Prior to the adoption of this project by the Reclamation Service there was already a cooperative irrigation system which included most of the lands now in the project. This old system consisted of a canal, called the Farmers' Ditch, about 17 miles long, heading in the Arkansas River about 1½ miles east of Deerfield. During flood stages in the river water was diverted into the canal and from the canal was distributed by laterals to the lands. There was no permanent diversion dam, but at low stages a temporary barrier was built, when needed, to give sufficient head for a flow in the canal. For the larger part of the irrigation season the flow in the river was insignificant. About 20,000 acres of irrigable land could be reached by the ditches, but not all of it was included in the system, only about 8,600 acres being served with the occasional irrigations.

4. The object of the works of the Reclamation Service is to supplement this insufficient irrigation by pumping from the underground flow of the Arkansas, the pumped water being turned into the Farmers' Canal near its head. The water users retain ownership and direction of the distribution system and control of the water after it is discharged into their canal. The works constructed by the Reclamation Service consist of a central electrical power plant, located near Deerfield, and 23 electrically operated pumping units. Oil is used for fuel. The capacity of the plant is 600 horsepower. The 23 pumping units are located about 1,000 feet apart, along a concrete-lined canal about 20,000 feet long. Ten of these stations are on the north side of the river and 13 on the south side. Water from the south part of the concrete canal passes under the river in a wooden-stave pressure pipe. At each of 3 of the pumping stations there is a group of twelve 15-inch wells, and at the other 20 stations the groups consist of 9 wells each. At each station the wells are connected by suction pipe to a vertical-shaft centrifugal pump driven by a 25-horsepower motor. The power house is built of concrete and pressed brick and the pumping stations of concrete. The power house and the installations therein, the pumping stations, and the concrete canal appear to be well built and in good condition. The farmers' ditches were not inspected by the board, but the reclamation officials state that they are in very poor condition.

5. *Water supply.*—Each of the 23 pumps has a rated capacity of 5 second-feet under the maximum head expected, and the calculations of the reclamation engineer indicated that the yield from each battery of wells would more than supply the pump. The entire pumping plant

was designed to supply 100 second-feet for an irrigation period of 150 days, or a total of 30,000 acre-feet. The duty of water is taken at 2 acre-feet at the farm, and allowing one-third loss for seepage, 30,000 acre-feet would suffice for the 10,000 acres in the project even though no water was obtained from the flood flow of the river. It was intended that the pumping should be discontinued whenever there was sufficient water diverted from the river. So far as the board is aware, no data were available when the project was undertaken to show what had been the average quantity of water diverted per irrigation season.

6. An appropriation of 200 second-feet of the underflow of the Arkansas at Deerfield was made on July 7, 1905, on behalf of the United States, and notice was duly filed and posted as required by the laws of Kansas. Subsequent to this filing the United States Sugar & Land Co. installed at Deerfield, above the Government line of pumping stations, a pumping plant to furnish water for irrigation of lands owned or controlled by the company. As the pumping at this place was apparently injuring the underground flow to the Government pumps, suit was instituted against this company in the State courts. It is understood that the suit has been withdrawn without having come to trial.

7. The records of the Reclamation Service show that under continuous operation the plant can not deliver the expected supply of water. During the season of 1909 the amount of water supplied to the irrigated lands from the several sources is given in the following table:

Months.	Length of time pumps were operated.		From pumping plant.	From Arkansas River.	From rainfall.
	Days.	*Hours.*	*Acre-feet.*	*Acre-feet.*	*Inches.*
April	22	12	1,227	.....	0.20
May	20	2	1,632	.....	2.06
June	12	17	1,036	1,265	3.28
July	19	18	1,745	1,818	6.22
August	19	4	1,810	1,844	.81
September	2	12	105	3,144	1.20
Total	96	17	7,555	8,071	13.77

This pumping represents an average rate for the 96.7 days of about 39 second-feet, but the available records do not show whether this represents the maximum possible output for long periods of pumping. The Director of the Reclamation Service stated in one of his printed reports:

> With the available water supply, and without assistance from river water or rainfall, it is believed that not more than 4,000 acres could be properly irrigated.

From the above information the board concludes that the supply of water, including both river and pumped water, will be insufficient in dry seasons for the full irrigation of the area included in the project.

8. Shortly after they were installed a test of the pumps showed that they had the rated capacity, and the shortage in the anticipated output must be due to the failure of the wells to furnish water to the pumps. The continuous operation of the pumps soon lowers the water level in the vicinity of the wells, and the flow through the sub-

soil is not sufficiently rapid to prevent this. Whether the proximity of the plant of the sugar company affects this supply to the pumps is not known; nor can it be stated what effect a more widely distributed location of the wells would have on the output. The indications are, however, that the deficiency is due to a much slower rate of underground flow than was estimated when the plans for the project were adopted and that a wider dispersion of the wells would have produced better results.

9. The experiment has been made of operating the pumps in groups, the object being to allow the water plane to recover its normal level at the idle groups, the pumps actually operating thus having less lift for a limited time. These experiments are reported as promising better results than has been possible when all the pumps are working together. It is not believed, however, that the present plant when operated either on this plan or operated continuously can deliver sufficient water for the irrigation of the 10,656 acres in the project.

10. *Lands.*—There are in the project 10,656.41 acres of irrigable land, all of which is in private ownership. Only 9,625 acres of this area is covered by the contract with the water users' association for the return to the reclamation fund of the cost of the project. The project was opened by public notice of March 6, 1908, the construction charge being announced at $35 per acre and the operation and maintenance charge at $2.75 per acre per year. On November 30, 1908, another public notice was issued, which raised the construction charge to $37.50 per acre for land which had not made application for water and for such lands which, having made application under the first notice, desired to come under the second notice in consideration of a delay of one year in the collection of the first installments. It has not been ascertained what proportion of the area is subject to the $37.50 charge and what to the $35 charge. The total number of acres covered by water right applications is 6,976, divided into 75 holdings.

11. The average elevation of the irrigable area is about 2,900 feet above sea level. The range of temperature is from —20° to 105° F. The average annual rainfall on the irrigable area is 20 inches, and in normal years it is sufficient to permit farming without irrigation. The irrigations ordinarily obtainable during the summer reenforce the rainfall, and it is only in the occasional very dry years that fair crops can not be obtained without the aid of pumped water. Under average conditions, however, additional water is necessary for a full irrigation, and a full irrigation means larger yields from the land. The pumped water therefore serves in ordinary years to increase the yield per acre and in dry years is an insurance against failure of crops. The rainfall during the season of 1910 has been above the normal, and while no pumped water was supplied to the lands in the project good crops were produced. The character of the soil in the project is fertile, black, sandy loam. The principal products are alfalfa, sugar beets, melons, sweet potatoes, small fruits, and grains. Alfalfa can be depended on for from two to four cuttings per year and sells at from $6 to $10 per ton in the stack. Sugar beets average about 9 tons to the acre, and can be sold to the Garden City Sugar Beet Factory at $5 per ton.

12. *Present conditions.*—After the end of the irrigation season of 1909 only one irrigator paid the assessment for operation and maintenance, and therefore his lands were the only ones entitled to receive water during the season of 1910. In January, 1910, a conference was held between officials of the Reclamation Service and the directors of the water users' association, following which the directors stated in writing to the supervising engineer that—

> it would be unwise for them to recommend any action without a further consultation with the stockholders of the association; that they are not warranted, from the opinions expressed by the farmers, under the project in recommending any further expenditure for the purpose of experimenting with a view of increasing the water supply; and that in their opinion it is utterly impossible for the farmers to pay the running expenses of the pumping plant during the coming year for the amount of water which could probably be furnished.

As the association failed to provide for operating the plant or to agree to its operation on a rental basis, the plant was prepared for nonuse and—

> its operation discontinued until such time as the landowners made application for its operation and were willing to pay for the construction and operation of same and made some arrangement for the proper distribution of water.

13. There is now pending in Congress a bill which, if passed, will permit a readjustment of the terms of the contract with the water users' association. It is desired by the Reclamation Service that such agreement shall provide for sufficient Government supervision over the farmers' distribution system to insure less wasteful and unequal distribution of pumped water, and for the continuous operation of the plant throughout the irrigation season, with the requirement that the farmers shall " take the water in steady volume, day in and day out, whether it rains or not, and whether the river is in flood or not." Concessions by the Government would doubtless include the operation of the plant for several years, with assessments on the lands only for operation and maintenance and with no payments on the construction charges until the plant had passed the experimental stage and the irrigation system was being successfully operated. Whether or not the water users would accept the terms of a new contract on that basis is uncertain. At the meeting which the board held with the directors of the water users' association there was submitted a copy of a resolution unanimously adopted by the stockholders at their annual meeting on October 5, 1910. The substance of this resolution is that the " Government be asked to abandon the said project so far as this association is concerned, and we ask that all contract liens so far as the Government is concerned be released." Complaint was made to the board that the project has cost much more for construction and for operation and maintenance than had been promised; that the annual charges were more than the lands could pay; and that the capacity of the pumping plant was wholly inadequate; but no desire was expressed for any other form of settlement than the release of the lands from the liens and the abandonment of the project. They stated that they did not believe it would be just for the Government to make them pay for an experiment in pumping which had failed so far as their lands were concerned, but which was more or less useful as an experiment in the installation of pumping plants elsewhere.

14. Alternatives to the starting up again of this pumping plant are its sale by auction as it stands or the dismantling of the plant and the transfer of the machinery to other reclamation projects. Either of these steps would make necessary the cancellation of the contract with the water users' association and would result in a large loss to the reclamation fund. The board, therefore, considers that it is advisable to allow matters to remain as they are now until definite action has been taken by Congress on the bill referred to; and in the event of its becoming a law that an agreement be reached, if practicable, with the association which would permit the resumption of the operation of the plant, even though it be necessary in the agreement to provide for a considerable extension of the period in which building costs must be returned.

15. *Costs.*—The total of allotments on this project to December 31, 1910, is $419,000, of which there was on June 30, 1910, a small balance; but this balance will be exhausted during the lay-up of the plant by the salary of the caretaker and small incidental expenditures. Of the total expended, $21,817.07, or 5.6 per cent, was for field engineering and superintendence; $19,262.38, or 5.2 per cent, for clerical services on the project; $856.38 for the supervising engineer's office; and $11,990.58 for the Washington and Chicago offices, expert engineering, etc. Since only $142.50 has been collected to date for installments on building charge, and $104.50 for operation and maintenance, the total of the allotments, $419,000, approximately represents the investment of the United States. If the lien on the lands is regarded as of value equal to the charges against the lands, then the following table represents in an approximate measure the financial standing of this project:

Investment of the United States		$419,000
Building charges:		
4,885 acres (estimated), at $35.00	$170,975	
4,740 acres (estimated), at $37.50	177,750	
Charges against lands for operation and maintenance	18,466	
		367,191
Loss to fund		51,809

16. If the entire 9,625 acres of land under agreement are bound by the charge named in the second public notice, $37.50, the loss to the fund will be about $40,000. Thus, there will be a loss to the reclamation fund even though the lien on the land has a real value equal to the charge against the land.

17. *Summary.*—(1) This project lies entirely within the State of Kansas.

(2) The entire irrigable area of 10,656 acres is in private ownership.

(3) The power house and power installations, the pumping stations and the concrete canal appear to be well built and in good condition.

(4) The capacity of the pumping plant under continuous operation would be sufficient to supply the full amount of water needed for irrigation, provided the flow of water to the wells was sufficient to supply the pumps, but under the conditions actually existing the pumping plant can not supply sufficient water to irrigate more than a small part of the contemplated area. It can, however, be used to supplement the flood irrigations from the Arkansas River.

(5) The plant having been prepared for nonuse and its operation having been discontinued, the board believes that it should be kept in this condition until definite action is had by Congress on a bill now pending which will permit readjustment of the terms of the agreement with the water users' association, and that if this bill becomes a law, a new agreement should, if practicable, be reached with the association, which will provide for the resumption of operation of the plant, with suitable government supervision of the distribution of water, and for a delay in the collection of past assessments of building charges until the system is in successful operation.

(6) There will be a loss to the reclamation fund even though the lands repay all the charges assessed against them.

Section X.

HUNTLEY PROJECT, MONTANA.

1. The board visited this project on August 13, 1910, inspecting the engineering structures, the distribution system, and the irrigable lands. A public hearing was held at Huntley on the same day.

2. *Location.*—This project is located on the south bank of the Yellowstone River in Yellowstone County, Mont. Good transportation facilities are furnished by the Northern Pacific and the Burlington Railroads, both of which traverse the project.

3. *Description.*—The water for this system is taken into the main canal from the Yellowstone through concrete headworks, located about 2 miles above Huntley, no diversion dam being required to direct the necessary flow into the canal. The main canal has an initial capacity of 400 second-feet, is about 23 miles long, and supplies water for the laterals of the distribution system as well as for the high-line canal, which heads at the pumping station 1 mile east of Ballantine. Between the headworks and the town of Huntley the main canal passes through three concrete-lined tunnels, having an aggregate length of 2,654 feet. At the pumping station, located at a 34-foot drop in the main canal, there is installed an automatic pumping unit, consisting of a turbine wheel and a centrifugal pump mounted on the same vertical shaft. The pumping unit lifts 56 second-feet to a height of 45 feet, the pumped water being discharged into the high-line canal. This canal is 6 miles long and through its laterals supplies the bench lands between Ballantine and Fly Creek. The aggregate length of laterals in the system is 240 miles. Other important engineering structures are the wasteway at tunnel No. 3, the culvert carrying the main lateral under the new channel of Pryor Creek, the Fly Creek Syphon, and the channel for Pryor Creek. All of these works, as well as the headworks, the pumping station, and the drops and turnouts on the main canals, are built of concrete. The minor structures, on the laterals, are generally built of wood. All of the engineering structures, as well as the distribution system, were found to be well designed and well constructed. No evidence of leakage was observed in the main canals, and no extensive leakage in the laterals. Such leakage as was observed will,

doubtless, practically disappear as the ditches become seasoned. The project is stated to be 96 per cent completed.

4. *Water supply.*—The Government filing is for 750 cubic feet per second, which is more than sufficient for all irrigable lands which can be reached by the present system and its extensions, and the minimum discharge of the river at this point during the irrigation season is sufficient to render this filing secure.

5. *Lands.*—There is included in this project an irrigable area of 28,809 acres, all of which is public land subject to the reclamation act except about 3,190 acres. The project was opened by public notice dated May 31, 1907, the building charge being fixed at $30 per acre and the charge for operation and maintenance at $0.60 per acre per year. Approximately 6,000 acres of the public land is still open to entry. All of the land under this project was formerly within the ceded strip of the Crow Indian Reservation, and the public lands in this area must pay, in addition to the building charge, $4 per acre to the Crow Indians. One dollar of this is to be paid when the land is entered and the remaining $3 in four equal annual installments. The private land includes Indian allotments and lands purchased from the Indians. The farm unit for the public land is 40 irrigable acres and for the private land 160 irrigable acres. Water-right applications now cover 17,396 acres, but only 12,000 were actually cultivated during the season of 1910.

6. The average elevation of the irrigable area is 3,000 feet above sea level, and the range in temperature is from —35° to 100° F. The average annual rainfall is 12 inches, which is so distributed during the year as to permit dry farming, but only with very limited success. The lands are easy to put into cultivation and to prepare for irrigation. The ground water level is rising and drainage ditches will be required for part of the land.

7. The soil is of good quality and varies from sandy loam to clay. The principal crops are grain, potatoes, alfalfa, and sugar beets, the latter being one of the best paying crops and easily disposed of near by at the Billings (Mont.) sugar factory. Land not in reach of water is valued at about $4 per acre, while sales of land included in the project have recently been made at $50 per acre, with construction charges still to be paid. The land values and crop returns indicate that the land will readily bear the announced construction charge, plus the $4 to be paid to the Crow Indians, and that the public land would have been entered under the land laws even had the building charge been as high as $35 per acre.

8. The size of the farm unit appears generally to be satisfactory and to be regarded as sufficient for supporting a family, although several statements were made that 40 acres was insufficient for that purpose and that for the least desirable lands in this project the farm unit should be increased to 80 acres.

9. *Operation and maintenance.*—Due to the fact that new canals are usually more or less pervious, several years of operation are required before the canals are well seasoned, and therefore the annual cost of repairs is higher at first. The first few years of operation also develop, as a rule, the necessity for certain betterments—for example, the necessity for the extension of concrete linings at drops, for additional check weirs, for additional control gates, etc. This, so far, has been the condition of the Huntley project, and in conse-

quence the annual cost of operation and maintenance on the project has considerably exceeded the collections therefor. Another reason for this annual deficit is that only a portion of the irrigable area is taken up and is assessed for operation and maintenance, while the actual cost of operating and maintaining the system is practically the same whether or not all the lands are being irrigated. For 1909 the excess of cost over collections for operation and maintenance was about $36,000, and for 1910 it is estimated at about $14,000 to $15,000. Now that the ditches are fairly well seasoned and a large part of the necessary betterments have been made, the total annual cost of operation and maintenance should hereafter be less, while the number of acres contributing will increase from year to year. Since the project has been opened, 60 cents per acre has been charged each year for operation and maintenance. The Reclamation Service states that in a few years the actual cost per acre per year will not be more than 50 cents, and if the 60-cent rate is continued the difference can be applied toward reduction of the deficit for operation and maintenance.

10. *Costs.*—The following table shows the probable deficit on this project at the end of the present calendar year:

Debits:		
Building costs to June 30, 1910		$842,887.10
Operation and maintenance costs to June 30, 1910		89,497.86
Deficit for 1910 for operation and maintenance (estimated)		15,000.00
		946,644.23
Credits:		
Building charges returnable, 28,809 acres, at $30	$864,270.00	
Sale of town sites	12,657.25	
Collected or accrued for operation and maintenance to June 30, 1910	15,795.15	
		892,722.40
Difference		53,921.83

This probable deficit may be reduced by additional sales of town sites. On the other hand, it will probably be increased somewhat during the next year or two by excess of expenditures over collections for operation and maintenance.

11. *Extensions.*—It is proposed to extend both the high line and the main canal to cover additional irrigable lands. The total area to be added by the proposed extensions is 4,035 acres, of which all is public land except about 900 acres of private land or Indian allotments. Since the intake, the main canals, and other works have sufficient capacity for this increased acreage, the proposed extension of the distribution system should be regarded rather as the completion of the project than as an extension. It is estimated by the Reclamation Service that the proposed work will cost approximately $110,000. It is believed by the board that the irrigable lands within the proposed extensions will bear a construction charge of $35 per acre, or possibly more, plus the payment of $4 per acre to the Crow Indians. If this area is opened at $35 per acre, the probable deficit on this project will be considerably reduced. This extension is regarded by the board as feasible from both an engineering and an economic standpoint, but it is not considered advisable that the work be undertaken until the larger part of the remaining public lands are taken up.

12. *Summary.*—(1) This project is entirely within the State of Montana.

(2) Of the 28,809 acres of irrigable land in the project about 89 per cent is public land subject to the reclamation act.

(3) Of the 4,035 acres of irrigable land in the proposed extension about 78 per cent is public land subject to the reclamation act.

(4) All of the engineering structures, as well as the distribution system, are well designed and well constructed.

(5) The Government filing for water is more than sufficient for all irrigable land in the project and its proposed extension, and the minimum discharge of the river at this point is sufficient to render this filing secure.

(6) The lands within the project will readily bear the announced building charge of $30 per acre, and those in the proposed extension will bear a charge of $35 per acre, or possibly more, plus the $4 per acre required to be paid to the Crow Indians.

(7) The proposed extension is regarded by the board as feasible from both an engineering and an economic standpoint, but it is not considered advisable that the work be undertaken until the larger part of the remaining public irrigable lands are taken up.

(8) The following allotment is recommended for the four years, 1911–1914, inclusive:

From the fund---------- $110,000

Section XI.

MILK RIVER PROJECT, MONTANA.

1. The board visited the lower part of this project on August 18 and 19, 1910, inspecting the Nelson Reservoir site, the Dodson Dam, the Dodson South Canal, and the irrigable lands; and on August 24, 25, and 26 inspected the sites for the St. Mary Lakes Storage Dams, that of the St. Mary River Diversion Dam, that of the Swift Current Diversion Canal, and the line of the St. Mary Diversion Canal. Public hearings were held at Hinsdale, Saco, and Malta on August 18, and at Harlem, Chinook, and Havre on August 19.

2. *Location.*—The irrigable area of this project lies in a narrow strip on both sides of the lower Milk River, in the counties of Valley and Chouteau, Mont. The storage and diversion works for the water supply from St. Mary Lakes are in the Blackfeet Indian Reservation, in western Montana. The Great Northern Railway traverses the entire irrigable area, and with its numerous stations gives short wagon hauls for the farm products.

3. *Description.*—The approved plans for the development of this system provide for the diversion of a part of the flow of the St. Mary into the headwaters of the Milk River. This diverted water is to supplement the water in the Milk River in the irrigation of lands in the lower valley of the latter stream.

4. *River systems.*—St. Mary River has its source in the two large lakes of the same name, whence it flows north through Canada into

Hudson Bay. Milk River has its sources near the St. Mary Basin, but is separated therefrom by a glacial ridge. Milk River flows north into Canada, thence east for about 200 miles, finally turning south and reentering the United States. A treaty was signed in 1909 between the United States and Great Britain which provides for the division of the waters of the two river systems on the following basis: These streams are to be treated as one stream for the purposes of power and irrigation; the waters thereof are to be apportioned equally to the two countries, but in order to afford a more beneficial use to each country, more than half may be taken from one stream and less than half from the other by either country; the prior right is recognized of the United States to 500 second-feet of the flow of the Milk River from April 1 to October 31 each year, or so much of such amount as constitutes three-fourths of the natural flow, and a similar prior right of Canada is recognized to the St. Mary flow; and, further, the United States may use the channel of Milk River lying in Canada for passing through Canadian territory the water diverted from the St. Mary.

5. *Diversion canal.*—Water is to be diverted from the St. Mary River to the North Fork of the Milk River, through the proposed St. Mary Canal, which will be entirely within the United States. The canal is to have a capacity of 850 second-feet, and will be 26 miles long. The principal structures will be the headworks tunnel and controlling works; Duck Creek crossing, Terror Creek siphon, and sluiceway; Hall Coulee siphon, and the drop into the North Fork. The formation through which the canal will be constructed shows evidence of having slipped, and considerable difficulty may be anticipated from slides. About 3 miles of the canal near its upper end may have to be lined with concrete. Some work has been done on this canal near the head and on another section a few miles from the lower end.

6. *Storage.*—The natural flow of the St. Mary is not sufficient to supply the prior rights of Canada and at the same time to permit the diversion to the Milk River of the additional amount of water required in that stream for the irrigation of the contemplated acreage. The approved plans, therefore, contemplate storage in the St. Mary Lakes. These two lakes are about 1¼ miles apart, and are connected by a small stream, the difference in the elevation of the two lakes being 12 feet. It is proposed to provide storage in the two lakes for about 218,000 acre-feet. Several plans for such storage were proposed, but the one now regarded by the Reclamation Service as the most desirable is the construction of a dam at the outlet of each lake, and of a canal connecting the lakes sufficiently low in elevation to permit the drawing down of the upper lake to a lower level than is now possible. The proposed storage dams are to be of the earth-fill type, with surfaces covered with riprap. A spillway is to be provided for each dam. It is the expectation that the construction of the dams will be postponed until storage becomes necessary.

7. To increase the available water, it is proposed to divert Swift Current Creek into St. Mary Lake above the storage dam by means of a canal and a diversion dam in the Swift Current.

8. *Milk River.*—This division of the project includes all works for the utilization of the water for irrigation in the lower Milk River

Valley. The works which have been under consideration for this division of the project are:

(1) *Chain Lakes Reservoir.*—The site for this reservoir is at the Chain Lakes on the Milk River. The earlier plans contemplated a high dam, forming a reservoir with about 750,000 acre-feet capacity, but examination indicated that the foundations are not suitable for a high dam. It may, however, be safe and practicable to construct a low dam at the foot of these lakes, if additional storage on Milk River becomes necessary.

(2) *Nelson Reservoir.*—This reservoir is to be formed by an earth embankment across the outlet of a natural depression south of the Milk River. The reservoir thus proposed will have an effective storage capacity of 142,000 acre-feet, and will be filled by water diverted from the Milk River through a feeder canal. The embankment will have a length of about 15,000 feet and a maximum height of 33 feet. The side slopes proposed are 3 to 1 upstream and 2 to 1 downstream; top width, 16 feet.

(3) *Chinook Diversion Dam.*—The proposed location of this dam is in the Milk River, about 3 miles below Chinook. The dam has not been designed, but is to be of the same type as the Dodson Dam.

(4) *Chinook North and South Canals.*—These canals are to head at the Chinook Dam, and are to supply water for the Chinook division, which lies on both sides of the river. The north canal is to be 38 miles, and the south canal 24 miles long.

(5) *Dodson Diversion Dam and Headworks.*—The Dodson Dam is located in the Milk River, about 3 miles above Dodson, and is completed except for the proposed automatic crest. The concrete headworks on the south bank have been completed, but no work has so far been done on the headworks for the north bank. This dam is a rock-filled, timber-crib structure.

(6) *Dodson North and South Canals.*—These canals are to head at the Dodson Dam, and are to supply water for the Dodson division. The north canal is to be about 28 miles long and have an initial capacity of 200 second-feet, supplying water for the Dodson north unit. The south canal has been completed for 9½ miles, and partially completed for an additional length of 8 miles. It is to have a total length of 42 miles, an initial capacity of 900 second-feet, and will supply water for the Dodson south unit, for the Bowdoin Canal, the Ashfield Canal, and Nelson Reservoir. The Bowdoin and Ashfield Canals are to carry water for their respective units. In the Dodson south unit the system of laterals has been constructed for about one-half the unit.

(7) *Nelson Reservoir South and North Canals.*—Both of these canals will head in Nelson Reservoir. The south canal is to be about 22 miles long and have an initial capacity of 250 second-feet. It will supply water to the Nelson Reservoir south unit, and, when necessary, to the Milk River for use in the Vandalia unit. The north canal will have a length of 47 miles, and an initial capacity of 250 second-feet, and will supply the Nelson Reservoir north unit, which lies on the north side of the Milk River. The canal will cross the river in a reinforced concrete siphon.

(8) *Vandalia Dam.*—The site for the proposed dam is in the Milk River, about 4 miles west of Vandalia. The dam has not been designed, but will be of similar type to the Dodson Dam.

(9) *Vandalia Canal.*—This canal will head at the Vandalia Dam, and will supply water to the Vandalia-Glasgow unit. The canal will be about 38 miles long, and will have a capacity depending on the acreage of the unit, which has not yet been determined.

9. *Comments on engineering structures.*—The completed structures in the Dodson division were found by the board to be well constructed. Most of the structures proposed for the complete system are only tentatively designed at present, but no engineering works of special difficulty are contemplated. The St. Mary Diversion Canal will probably be difficult to maintain on account of the expected movement in the material in which the canal is to be cut. This remark applies especially to the second 3 miles from the head, where considerable sliding has already taken place. It is proposed to provide good open drainage to prevent saturation of the slopes above the canal and thereby reduce the tendency to slide.

10. *Water supply.*—The Reclamation Service has made a comprehensive study of the water supply of the project, and a summary of that study with comments thereon is appended to this report. It is found that after satisfying Canada's prior right 850 second-feet can be diverted from St. Mary River for a period of seven months each year if suitable storage is provided in St. Mary Lakes. The amount of storage that would have been required to maintain this flow during the period 1903–1909 varied from 75,000 acre-feet to 175,000 acre-feet. The plans contemplate 218,000 acre-feet of storage in these lakes, thus providing for even a lower flow in St. Mary River than has occurred since 1903.

11. The study also shows that during the same period the part of the natural flow of Milk River to which the United States is entitled by treaty, augmented by the 850 second-feet from St. Mary River, would have been sufficient to provide water for 215,000 acres at the assumed duty of $1\frac{1}{2}$ acre-feet per acre measured at the farm, and that this amount of water could have been delivered to the land through the canal and reservoir system as planned.

12. In this study a uniform rate of delivery of water to the lands during a period of seven months is assumed. As the growing season is only about five months it is questionable whether such deliveries would meet irrigation requirements. The storage provided in Nelson Reservoir would serve to regulate deliveries in accordance with the demand so far as the lands below it are concerned, but this storage must also serve to equalize the variable run-off of different years.

13. While the amount of water available is sufficient for the needs of the project, it seems probable that additional storage on Milk River will be necessary if the delivery of water is to be limited to the growing season. It further appears that the terms of the treaty will be complied with, as the quantities of the combined flow of St. Mary and Milk Rivers proposed to be used in the United States both for this project and to satisfy prior rights will not exceed one-half of the combined flow of these streams as measured at the international boundary.

14. The supervising engineer stated, "Before the United States can safely undertake the construction of any extensive irrigation works, it will be necessary that the rights of the various appropriators of water from Milk River and its tributaries be definitely fixed and made a matter of court record." The board believes that necessary steps to obtain such adjudication should be taken at once.

15. *Lands.*—The irrigable lands of the project logically fall into three principal divisions and one smaller division. In the table below are given these divisions with their natural subdivisions, which, for convenience, are designated as units. The acreage of irrigable lands has been variously stated, but the figures given are those on which the construction estimate is based. In the table is shown also the acreage of lands now included in private and Indian irrigation systems, but which, it is expected, will come into the Government project:

Chinook division:			
(1) Chinook north unit—			
Under private canals	16,000		
Not under private canals	22,000		
		38,000	
(2) Chinook south unit—			
Not within Indian reservation—			
Under private canal	9,000		
Not under private canal	4,000		
Within Indian reservation—			
Under Indian canal	10,000		
Not under Indian canal	20,000		
		43,000	
			81,000
Dodson division:			
(3) Dodson north unit—			
First half unit	6,000		
Second half unit	8,000		
		14,000	
(4) Dodson south unit—			
Head to Malta divide	15,000		
Malta Divide to Ashfield Canal	5,000		
		20,000	
(5) Bowdoin unit		17,000	
(6) Ashfield unit		10,000	
			61,000
Nelson Reservoir division:			
(7) Nelson Reservoir south unit		20,000	
(8) Nelson Reservoir north unit		20,000	
			40,000
Vandalia Canal division:			
(9) Vandalia-Glasgow unit			14,000
Total			196,000

16. In the Dodson south unit about 8,000 acres are now in reach of flood water, supplied through the Dodson South Canal, but no land has been officially declared open for irrigation.

17. The status of the lands as to ownership was furnished to the board only for an assumed acreage of 248,000 acres. Assuming that the relative proportions of the different classes of land is approximately the same for the reduced as for the larger acreage, the following represents the approximate classification of the lands: Public lands entered, subject to the reclamation act, 64,000 acres; public land unentered, 12,000; State land, 10,000 acres; private land and Indian land, 110,000 acres. In addition to this area of 196,000 acres, there are other areas within the boundaries of the project now under private ditches taking water from Milk River or from Willow and Rock Creeks, but these can not be irrigated from the proposed Government canals.

18. The average elevation of the irrigable area is about 2,200 feet above sea level and the range of temperature is from —45° to 100° F.

The average rainfall on the irrigable area is about 13 inches. Although dry farming is possible, it is not usually successful. A single flood irrigation sometimes is sufficient to insure a good crop. The soil is a fertile sandy loam, well adapted to raising hay, grain, alfalfa, and vegetables. Some alkali is present in places, and drainage ditches will be required for part of the area in order to prevent swamping. Statements from local sources indicate a valuation of land without water of about $20 per acre and of land under irrigation of $75 to $100 per acre. None of the area has yet been opened and no construction charge has been fixed. The water users' association, which covers the lands below the Dodson Dam, has petitioned for water at whatever the necessary cost may be. It is believed by the board that in view of the probable returns from the lands when under full irrigation the land will readily bear any reasonable building charge.

19. *Costs.*—To June 30, 1910, there has been expended on the St. Mary storage and diversion $265,842.95, and on the Milk River irrigation system $538,396.74. The estimates for completion of this project, as prepared for the board, are as follows:

(*a*) St. Mary storage and diversion:		
Swift Current diversion		$30,000
Temporary St. Mary Diversion Dam		10,000
Out-take tunnel		59,123
Regulating works		10,810
Duck Creek controlling works		9,011
Division 1 of canal		613,700
Division 2 of canal		107,700
Division 3 of canal		126,500
Division 4 of canal		158,200
Halle Coulee siphon		55,160
Bridges, spillways, drops, etc		59,500
Storage dam, Lower St. Mary Lake		238,620
Department expense, engineering, and contingencies, 20 per cent		295,665
Total		1,773,989
Deductions:		
Work done on canal	$150,000	
Equipment on hand	15,000	
		165,000
Additional expenditures required		1,608,989
(*b*) Milk River irrigation system:		
Automatic crest Dodson Dam		10,000
Dodson North Canal, laterals, etc		104,000
Dodson South Canal, laterals, etc		344,000
Bowdoin Canal, laterals, etc		267,000
Vandalia Dam, canal, laterals, etc		475,000
Dodson South Canal extension, laterals, etc		363,000
Nelson Reservoir		380,000
Nelson Reservoir, south canal, laterals, etc		330,000
Ashfield Canal, laterals, etc		155,000
Dodson North Canal extensions, laterals, etc		160,000
Nelson Reservoir, north canal, laterals, etc		435,000
Chinook Dam		75,000
Chinook North Canal, laterals, etc		470,000
Chinook South Canal, laterals, etc		556,000
Total estimated future expenditures		4,124,000
Allotments to June 30, 1910		593,000
Total estimated cost to complete		4,717,000

20. In the above estimate the proposed storage dam for the upper St. Mary Lake is not included nor the amount already expended for surveys, etc., in connection with the St. Mary storage and diversion. For these items approximately $400,000 should be added, making the total estimated cost of the St. Mary storage and diversion about $2,174,000 and the total estimated cost of the whole project about $6,891,000. The total of allotments to December 30, 1910, on the project is $941,000, and therefore additional allotments to the amount of about $5,950,000 are required for the completion of the project.

21. Since the above estimates are more or less approximate, and since the irrigable acreage to be included in the project is more or less uncertain, only a rough approximation can be made as to the probable building charge per acre. Based on the above estimates and on an acreage of 196,000, and assuming that the lands of the present private irrigation system will come into the Government project at one-half the acre building charge, then the probable building charge will be $38 to $39 per acre.

22. *Comments.*—Owing to the international features of this project it has just claim for national assistance. The large amount of money already expended, which would be lost if the project were not completed, the relatively large amount of public land, the productiveness of the land and its ability to pay the probable building cost, all make it desirable to continue work on the project until completion. Attention is invited to the fact that the par value of the stock of the water users' association is only $25 per share. As this amount is said to be the limit of the recorded lien against the land, it would render the security for the cost of the project more certain if the par value of the stock is raised to a figure which will cover the probable building charge.

23. *Summary.*—(1) The irrigable land of this project lies entirely within the State of Montana, but the project is international in character because of the division of the flow of St. Mary and Milk Rivers between Canada and the United States and the conveyance of the water belonging to the United States through Canadian territory.

(2) Of the total area of 196,000 acres which it is proposed to include in the project, about 39 per cent is public land subject to the reclamation act.

(3) The project is feasible, both from an engineering and an economic standpoint.

(4) The amount of water available, with the storage proposed, is sufficient for the needs of the proposed project, but additional storage may be needed on Milk River if the delivery of water is limited to the growing season. The proposed use in the United States of the combined flow of St. Mary and Milk Rivers, both for this project and for satisfying prior rights, will not exceed one-half of the combined flow of these streams, as measured at the international boundary.

(5) The total estimated cost of this project is about $6,891,000, of which $941,000 has already been allotted.

(6) The land will bear the construction charge, which is estimated to be about $38 to $39 per acre.

(7) In view of the international features of this project, the large amount of money already expended, the large amount of public land included, and the value of the land and its ability to bear the prob-

able building charge, the project is a worthy one and work should be continued at an economical rate until completion.

(8) The following allotments are recommended for the four years 1911–1914, inclusive:

From the fund	$2,950,000
From the loan	1,000,000
Total	3,950,000

Section XII.

SUN RIVER PROJECT, MONTANA.

1. The board, on August 21, visited the Fort Shaw unit, Willow Creek Reservoir, the lands on the Greenfield Bench, the line of the High Line Canal and other proposed canals in that vicinity; on August 22, the sites of the diversion dam at Sun River Canyon and of the Warm Springs Dam; on August 23, the line of the proposed North Supply and Teton Slope Canals, the site of the Pishkun Reservoir and the lands adjacent. Hearings were held at Fairfield on August 21, and Chouteau on August 23.

2. *Location.*—The Sun River project is designed to irrigate lands lying in the valleys of the Sun River and the Teton River in western Montana just east of the Rocky Mountain divide. The lands and the water supply are entirely within the State of Montana.

3. A branch of the Great Northern Railway passes north and south through the eastern part of the project. The nearest station to the Fort Shaw unit is Vaughn, distant 6 miles. It is expected that a branch will be constructed up the Sun River Valley and that probably a transcontinental road will within a few years cross the divide by way of the valley of the South Fork of the North Fork.

4. *Description.*—Water for this project will be taken mainly from the North Fork of the Sun River. A storage reservoir will be constructed near Warm Springs on the North Fork of the North Fork. The supply in this reservoir will be increased by water brought by canal from the South Fork of the North Fork and by tunnel and canal from Bowl Creek on the west of the Continental Divide. After leaving the reservoir the water will flow about 12 miles in the channel of the North Fork until it reaches the North Fork Canyon, where it will be diverted by a concrete dam built in the canyon. From this point it will be carried in two canals, one on each side of the river, called the North Supply and the South Supply Canals. Additional storage capacity will be provided by two reservoirs, the Pishkun Reservoir at the end of the North Supply Canal, and the Willow Creek Reservoir, supplied by the South Supply Canal. The water supply is to be augmented by various secondary streams, such as the South Fork of the Sun River, Willow Creek, and Deep Creek. The Pishkun Reservoir will discharge—first, into the High Line-Greenfields Canal; and, second, by a different opening and at a lower level, through Deep Creek into the Teton Slope Canal. Willow Creek Reservoir discharges into the Sun River, and the water is thence

diverted into the Fort Shaw Canal. The water stored in the Willow Creek Reservoir is to be used for the Fort Shaw unit and also for the private irrigation lands on the Lower Sun River, thus permitting all of the North Fork water to be taken into the Government system instead of allowing a portion of it to pass down the river to satisfy these prior rights. A possible extension of the project is the use of Lake Benton as a reservoir supplied from the Teton Slope Canal to irrigate lands in the vicinity of Great Falls. It would use surplus flood water when available. Willow Creek Reservoir is now under construction, with a temporary height of dam of 70 feet, to store the waters of Willow Creek and tributaries. The dam will later be increased in height to provide for additional storage for the surplus waters of the North Fork. The canal and lateral system of the Fort Shaw unit is practically complete. No work has been done on the other parts of the project, except the necessary surveys.

5. *Water supply.*—The annual run-off of Sun River ranges from 500,000 acre-feet to 1,000,000 acre-feet. To provide for years of low water, it is proposed to increase the supply of water by diversion from Bowl Creek, on the west side of the divide, which has an estimated run-off of 8,000 to 9,000 acre-feet. Stream gaugings at a number of points have been made since 1905, but the data even for this period are not sufficiently complete to warrant any definite conclusions as to the supply that can be made available for this project through the reservoir and canal system as planned.

6. In an analysis, prepared by the supervising engineer, which is appended, the run-off of certain parts of the watershed has been assumed, the assumptions being based on the size of drainage area and the character of the topography as compared with the known run-off of certain other areas. It has also been assumed that the winter flow of the South Fork of the North Fork can be diverted into the Warm Springs Reservoir during 10 months each year, and that that of the North Fork below the Warm Springs Reservoir can be diverted into the north and south supply canals during the same period. It is believed, however, that eight months' use of these canals is all that can be counted upon in this climate. Based on these assumptions, it was found that, after satisfying prior rights and providing for the Fort Shaw unit, there would have been available for north side lands the following quantities of water:

Total available supply for north side lands.

1905	322,700
1906	305,500
1907	740,000
1908	757,000
1909	784,000
1910	540,000

7. The duty of water is assumed to be $1\frac{1}{2}$ acre-feet per acre measured at the farm corresponding to a diversion duty of 2 acre-feet per acre. On this basis there would have been a sufficient supply in 1906 for 152,000 acres, while during 1907, 1908, and 1909 there would have been sufficient for 350,000 acres.

8. The proposed reservoirs will permit a certain amount of water to be carried over from years of high run-off to years of low run-off, but these reservoirs must also act as equalizers of the annual flow.

Further information as to the distribution of the run-off throughout the year at different points of the system is necessary before the hold-over capacity of the reservoirs can be determined. As the limited gauge readings show two successive years of low run-off, only half of the hold-over capacity can be relied upon to supplement the flow in such years. Assuming the hold-over capacity at 200,000 acre-feet, it does not seem wise with the system as planned to count on an annual supply of over 400,000 acre-feet, or sufficient for the irrigation of 200,000 acres.

9. *Land.*—The rainfall on the irrigable area is about 12 inches. The average elevation is 3,700 feet above sea level. The amount of land to be irrigated has been variously estimated, and as there is much more land of good quality than water available, it will depend on the water development. The number of acres proposed in the project is from 283,000 to 322,000, divided as follows:

	Acres.
Fort Shaw unit, lying along south bank of the Sun River	16,000
High Line and Greenfields unit along north bank of the Sun River and on divide between Sun and Teton Rivers	94,000
Teton Slope and Muddy Creek	173,000
Proposed extension in vicinity of town of Power	14,000
Lake Benton system	25,000
	322,000

These areas are not very definitely determined. The ownership is distributed about as follows:

	Acres.
Public land withdrawn from entry	138,000
Land entered under reclamation act	93,000
State land	25,000
Private land	50,000
Fort Shaw unit under irrigation	16,000
	322,000

10. The land is of good quality, especially on the benches. The soil is sandy loam, clay, gravel, and alluvium. Water is necessary to insure good crops, dry farming giving uncertain results, though practiced in several localities. The land lies well for irrigation, includes but few nonirrigable areas, and permits economical development of canals and laterals. Drainage ditches will be necessary. Below the Fort Shaw unit private land has been under irrigation for some years, and large areas have become swamped due to over irrigation and lack of drainage. As this region is only semiarid, a duty of 1½ acre-feet at the farm is considered sufficient. The crops are hay, alfalfa, grain, vegetables, and in the future probably sugar beets.

11. Land without water is worth $5 to $20; with water, $75 to $100 an acre.

12. About 1900 the construction of a canal called the Kilmore Co-operative Canal was begun in order to irrigate the Greenfields bench, and about 4 miles of canal were constructed. The withdrawal under the reclamation act in 1903 of the public lands caused a suspension of this work, leaving the settlers without the anticipated water.

13. *Fort Shaw unit.*—The only land opened for settlement in this project is the Fort Shaw unit, an abandoned military reservation, opened May, 1908. This unit comprises 16,000 acres, of which 13,500 acres are public and 2,500 acres private land. There are 206 public

farms, averaging 88 acres of total area and 61 acres of irrigable area. There have been entered 163 farms, or 9,500 acres of public land, and 225 acres of private land have made water applications. In addition, 1,200 acres of Indian school reserve land receive water.

14. The Government unit is 40 to 80 acres, dependent on location and soil. While this land does not produce high-priced crops, there does not seem to be any objection to the small-size farms, as 40 per cent of the farms entered contain 40 acres or less of irrigable land, 59 per cent 60 acres or less, and only 10 per cent over 80 acres.

15. The assessed cost of construction for the unit is $30 per acre and of operation and maintenance $0.50 per acre per year.

16. *Engineering structures.*—The only completed portion of this project is the Fort Shaw unit. Water is taken through concrete headworks from the Sun River and distributed by a system of canals, of which one-third mile has a capacity of greater than 300 second-feet, 17 miles of between 50 and 300 second-feet, and 88 miles less than 50 second-feet. The turnouts are mainly of timber. The drops are of concrete. The slope of several of the laterals is large and erosion of the banks frequent. This can be readily corrected by insertion of drops, or by other means.

17. The Willow Creek Dam is now under construction to a temporary height of 70 feet, and side slopes of 3 to 1. When additional storage is needed it will be raised to a final height of 110 feet, with a top width of 20 feet, upstream slope of 3 to 1 and downstream slope of 2 to 1. The spillway for the lower dam will be through a gap in the surrounding hills. This will be closed by a dike when the dam is raised, and the spillway will be through another and higher gap. The outlet is by a tunnel passing around the end of the dam. The subsoil is glacial drift, 15 feet or less in depth, lying over sandstone. Four cut-off trenches are excavated to the underlying rock and filled with selected puddled material. The storage capacity when the dam is completed to full height will be 84,000 acre-feet. The capacity of the temporary reservoir is 16,700 acre-feet.

18. The proposed Pishkun Reservoir Dam and other earth dams are low and offer no difficulties of construction.

19. The diversion dam in the Sun River Canyon will be of concrete of about 72 feet maximum height, and a top length of 150 to 160 feet.

20. The site of the proposed dam for the Warm Springs Reservoir is located on the North Fork of the North Fork, about 12 miles above the canyon. It is planned to be a rock-fill dam backed with earth placed by the hydraulic process. The upstream slope is 3 to 1. It was first proposed to make the downstream slope 1 to 1, and the estimates were made by the Reclamation Service on that basis. It is now proposed to make it 1½ by 1. The outlet will be by tunnel. Ample spillway is provided through a depression in the surrounding hills. Rock is found at a small depth below the creek bed. The material for construction is to be clay, coarse and fine gravel, sand, and some bowlders. The capacity is to be 156,800 acre-feet.

21. Descriptions of Willow Creek and Warm Springs Dams with estimates are appended.

22. *Comments.*—The works in the Fort Shaw unit are well designed and constructed.

23. While it is at present proposed to raise the Willow Creek Dam from its present proposed height of 70 feet to a height of 110 feet,

this increase will not be needed for several years, and it is possible that the full height of 110 feet may not be needed. The reason given for adopting a rock-fill dam at Warm Springs is the high cost of a masonry structure constructed at such a distance from the railroad. As this dam will not be constructed for several years, possibly better railroad facilities will then exist, a further consideration is recommended of the type of this dam. The south side supply canal, as proposed, is to have a capacity of 1,100 second-feet. As is shown in Table 4 of the water-supply analysis, the maximum yearly amount that would have passed through the canal during the period 1905–1910 was 52,000 acre-feet, or only 24 days' flow when running full. As this amount can readily be diverted during the nonirrigating season with a canal of much less capacity, a further study is suggested.

24. *Costs and estimates.*—There has been allotted to December 31, 1910, $672,000, which has been used in constructing the Fort Shaw unit, in beginning the Willow Creek Reservoir, and in surveys and examinations for the complete project. The total estimate of cost, including work already done, is as follows:

Fort Shaw unit, including share of storage cost and examinations	$672,000
Willow Creek Reservoir, to complete	266,600
Bowl Creek Canal	25,000
Warm Springs Reservoir	664,100
Canyon Headworks	118,500
North Supply Canal	1,157,700
South Supply Canal	130,300
Pishkun Reservoir	183,600
High Line and Greenfields Canals and extensions	1,528,200
Teton Slope Canal and extensions	2,427,100
Muddy Creek extension	319,900
Power extension	210,000
Benton Lake system	432,600
	8,135,600

25. This estimate is for the completion of the proposed project of 322,000 acres. If the Power extension and the Benton Lake system are omitted this will reduce the total estimated cost to $7,493,000 for 283,000 acres.

26. It is thought by the board that this estimate is too low. In the Warm Springs Dam the unit costs for rock fill, earth fill, and riprap are all considered low, and in addition the proposed flattening of the rock-fill slope will increase the quantities. In the Canyon Headworks and the Willow Creek Dam some of the estimates of unit costs are also low. As the details of the project have not been worked out, the size of canals are not determined, and estimates on the canal system must be approximate. Having in view the uncertainties of much of the work, an item of 20 per cent for contingencies would be better than the 15 per cent adopted. It would be safer to make the estimate of the total cost as approaching $10,000.000 for the larger project and $9,000,000 for the smaller. The chief engineer of the Reclamation Service, in a communication dated October 29, 1910, makes approximately this recommendation.

27. These figures would make the cost of construction per acre from $30 to $32. As stated above in the discussion of the water supply, it does not appear certain that over 400,000 acre-feet can be counted on. This is sufficient for about 200,000 acres of land, and it may be necessary to reduce the project to this acreage. As the cost of the storage system is relatively small, it may be taken as approxi-

mately proportionate to the amount of land, and as all the land lies equally well for irrigation, the relative cost of the distribution system should be about the same for the smaller acreage. It may be assumed, therefore, that the building cost of 200,000 acres would be about $35 per acre. It is thought that the land could bear a cost not to exceed this amount. Further investigations with regard to the water supply and further surveys of the land to be irrigated are necessary before reliable estimates can be made.

28. *Summary.*—(1) The project is feasible from an engineering and economic standpoint.

(2) The lands and the water supply lie entirely within the State of Montana and to the east of the Rocky Mountains, except that a small proportion of the water may be diverted from the west side of the Divide.

(3) The total amount of land in the project will vary from 200,000 to 322,000 acres, dependent upon the amount of water available. Of this, about 70 per cent is public land subject to the reclamation act.

(4) The amount of water is sufficient for 200,000 acres, and it may prove after further investigation that it is sufficient for a larger area.

(5) The estimated cost may vary from about $7,000,000 to $10,000,000, depending on the amount of land included in the project. Of this $672,000 has been spent for the completion of the Fort Shaw unit and for surveys and examinations.

(6) The land can bear the cost of construction, estimated at about $35 per acre.

(7) The project is considered worthy and should be continued as soon as funds are available.

(8) Further examinations of the water supply and surveys of the land will be necessary in order to determine the extent of the project.

(9) The following allotment is recommended for the four years, 1911–1914, inclusive:

From the fund	$3,278,000

Section XIII.

LOWER YELLOWSTONE PROJECT, MONTANA AND NORTH DAKOTA.

1. The board visited this project on August 16 and 17, 1910, inspecting the principal engineering structures, the distribution system, and the irrigable lands, and held public meetings at Sydney and Valley View, Mont.

2. *Location.*—This project is located on the west bank of the Yellowstone River, partly in Montana and partly in North Dakota. It lies between the Northern Pacific and the Great Northern Railroads, but the center of the irrigable area is about 35 miles from the nearest railroad station. A new railroad is projected which, when built, will give good railroad facilities to the entire project. At present the railroad station for the southern part of the project is Glendive, Mont., and for the central and northern parts, Mondak, Mont.

3. *Description.*—The water for this project is taken from the Yellowstone River through concrete headworks, a diversion dam giving

the necessary head to cause a flow in the canal at low water. The dam and headworks are located about 17 miles below Glendive. The structures are described in the appendix to this section. Through the openings in the headworks the water passes into the main canal, and thence through the laterals and sublaterals to the lands to be irrigated. The main canal has a capacity at its head of 847 second-feet, and is now 62 miles long and ultimately will be about 70 miles long. There are now about 138 miles of laterals and sublaterals, with capacities of from 1 to 90 second-feet, and for the completion of the system 63 miles additional will be required. Important structures along the line of the main canal are the flume carrying the waters of Linden Creek over the canal, the Burns Creek sluiceway, the Burns Creek conduit, and the Fox Creek siphon and spillway, all of which structures are of concrete. These structures, as well as the canals and laterals, appear to be well constructed. Wood is the material ordinarily used for construction of turn-outs and other minor works on the laterals. Generally the engineering structures seem to have been constructed economically, although based on experience elsewhere in the United States the cost of the diversion dam appears to be high. It is thought that a dam equally secure and equally suitable could have been built for a more reasonable expenditure. The completion of the approved project involves, in addition to the extension of the distribution system, the installation of a pumping unit for raising water to the high-line lateral located at one of the drops in the distribution system.

4. *Water supply.*—The water supply for this project is more than ample, the minimum discharge being 4,500 second-feet, while the maximum capacity of the main canal is about 850 second-feet. The Government filing, made on October 30, 1905, is for 1,000 second-feet. The duty of water is figured at 2½ acre-feet per acre at the farm. The average annual rainfall on the irrigable area is 16 inches.

5. *Lands.*—Under the project as outlined and approved there is a total irrigable area of 62,280 acres, of which about 2,000 acres are State lands, about 5,000 acres belong to the Northern Pacific Railway, about 17,000 acres are public, the remainder being in private ownership. The railroad land is under agreement to be sold off in farm units. All the land is to be irrigated by gravity, except 2,314 acres, which are to be supplied by pumped water. Of the total acreage in the project, 35,395 acres were opened under the public notice of December 21, 1908, the building charge being fixed at $42.50 per acre. Practically all of this area is deeded land or land which has been taken up under the terms of the reclamation act, there being only about 20 farm units still open, and these are in the poorest part of the valley. The public land taken up in this project has been homesteaded in 160-acre tracts, which, under the terms of the reclamation act, must be reduced to conform to the size set for the farm unit—that is, 80 acres. Acreage in excess of 80 irrigable acres must be returned to the Government and lands so returned will give further opportunities to new settlers.

6. Before the project was started a large proportion of the owners of the private land entered into an agreement with the Government to take water from the system, and, in accordance with the law, all public land included in the project was so pledged. Since the Reclamation Service has been prepared to supply water for the 35,395

acres opened, only a small proportion of the farmers have filed application for water, there being now only about 13,000 acres for which the applications for water have been perfected, of which only 7,000 acres were actually irrigated this year. This failure to utilize the irrigation system is believed to be due partly to the fact that for several years the rainfall has been sufficient to produce fair crops, causing the farmers to postpone their applications; and, secondly, to the dissatisfaction with the construction charges, which the farmers very generally claim to have been promised would not be more than $30 per acre. The season of 1910 has been an unusually dry one, and unirrigated crops were mostly total failures. Many of those not using water would doubtless have applied for it this season had it not been that before water would have been furnished it was required that amounts due for operation and maintenance for 1909 must be paid. For the next season this condition will be more severe, since before water will be furnished one installment of the construction charges and two years' charge for operation and maintenance, a total of $8.50 per acre, will be required. The large majority of the farmers claim that few of them will be able to meet the installments of the construction charges as now required, but state that under a system of graduated payments they will be able to do so. It is understood that a bill is now before Congress which, if it becomes a law, will permit a readjustment of the terms for repayment of building charges after they have already been fixed by the Secretary of the Interior. The situation of the farmers under this project appears to justify some readjustment in this case. Dissatisfaction is also expressed with the requirement that homesteaders must give up all of their holdings except 80 irrigable acres, many claiming that they did not so understand the law when they entered their land. They state that they would be satisfied to sell the excess holding, but that it is unjust to require them to give it up without compensation for improvements. This condition, however, seems to be a consequence of their ignorance of the terms of the law.

7. The average elevation of the irrigable land is about 1,900 feet above sea level; the range of temperature is from —30° to 100° F., and the average annual rainfall is about 16 inches. The land lies on well-defined benches, is as a rule well adapted to irrigation, and is easily drained. The bottom lands are more or less covered with brush and are more liable to be uneven, and it is therefore more difficult to prepare them for irrigation. The soil is a deep, sandy loam, apparently fairly uniform in quality and easy to work. There is little alkali. The soil and climate are suitable for grain, alfalfa, etc., but the long wagon haul to market greatly decreases the net returns from these crops. Considering the certainty of a crop on irrigated land in dry years, as well as the more bountiful crops in ordinary years, the board believes that the land will bear the construction charges which have been set, and more readily so after the projected railroad is built. This charge of $42.50 per acre is, however, considered to be close to the limit of costs which the land will bear. Under present conditions it does not appear to be probable that farmers who are now two or more years in arrears for building charges and for operation and maintenance can perfect their applications for water. The accumulation of back charges, the quality of the land, which at present produces only hay and grains, the distance to the railroad, the

poverty due to the failure of this year's crop, have produced a condition which it seems can be remedied only by some modification of the present requirements which would permit the farmers to obtain one irrigated crop prior to any demand for back charges, or which would provide for a system of graduated payments.

8. The board believes that the farm unit of 80 acres is sufficient to support a family if it is properly worked. While the actual cost per acre for operation and maintenance has so far been much greater than the charge, which has been set at $1 per acre per year, it is probable that when the canals are well seasoned and when the bulk of the land is under irrigation that the cost per acre will not exceed $1, which appears to be a reasonable charge.

9. *Completion of the system.*—No extensions are proposed, but it is contemplated that the approved project shall be completed. The completion will involve only the extensions of the present and the construction of some additional laterals and the installation of the pumping equipment. The board regards the completion of the system as feasible and practicable, but it does not regard it as desirable that further large expenditures be made for this purpose until it is demonstrated that most of the acreage now in reach of the irrigation water is actually being irrigated and with satisfactory results; and, furthermore, that it will be wise to await the completion of the railroad before completing the system so as to render more probable successful results.

10. *Returns to the reclamation fund.*—The aggregate of allotments to date is $2,910,000, and the supervising engineer states that additional allotments to the amount of $613,000 will be required to complete the work, making a total of $3,523,000. Since the costs of operation and maintenance are paid out of the allotments from the reclamation fund, and since collections to cover such costs are returned to the fund through the land offices, the total of allotments for a project must be decreased by the collections (or accruals) for operation and maintenance in order to show the amount properly chargeable to construction. In the case of the Lower Yellowstone project, however, the collections for operation and maintenance to date have been only $12,067, which will probably be barely sufficient to cover the deficit for operation and maintenance for the next season. For this reason it is believed to be advisable to take $3,523,000 as the probable total construction cost of the completed system.

11. The 35,395 acres already opened at $42.50 should return $1,504,287.50. Subtracting this from the estimated total cost, the remainder is $2,018,712.50. If it is assumed that the lands not yet opened are to repay this amount, then the charge for construction would have to be fixed at about $75 per acre. On the other hand, assuming that the remaining area is to be opened at $42.50 per acre, the total expected return from the 62,280 acres will be $2,646,900. Under this assumption the loss to the reclamation fund will be $876,000. It is possible that before the remaining area is opened conditions will justify a charge per acre above $42.50, but in any event it seems inevitable that there will be a large loss on this project to the reclamation fund. Since for an estimated additional expenditure of $613,000 an area of 26,885 irrigable acres will be added, the completion of the project will, if the lands repay the charges, reduce the deficit from what it would be if the project was restricted to the area already opened.

12. *Summary.*—(1) This project is interstate in character, being partly in Montana and partly in North Dakota.

(2) Out of an area of 62,280 irrigable acres in the project only 17,000 acres, or 27 per cent, are public, subject to the reclamation act.

(3) The engineering structures and the distribution system are well constructed and economically designed and constructed, with the possible exception of the diversion dam and headworks.

(4) The completion of the project as outlined is feasible.

(5) No large expenditures should be made toward the completion of the project until the area already open is utilized with success.

(6) In the event of such successful utilization the project should then be completed as outlined.

(7) In the opinion of the board the farm unit of 80 acres is sufficient to support a family.

(8) If permitted by law some modification should be made in the terms of the contract with the farmers on this project which will enable them to obtain one irrigated crop prior to any demand for back charges, or which will provide for a system of graduated payments.

(9) There will be a large loss on this project to the reclamation fund.

(10) The estimated final cost of the project is about $3,523,000, of which approximately $2,900,000 had been expended prior to June 30, 1910.

(11) The following allotment is recommended for the four years 1911–1914, inclusive:

From the fund---------- $578,000

Section XIV.

NORTH PLATTE PROJECT, WYOMING AND NEBRASKA.

1. The board visited the Pathfinder Dam on August 1 and 2, the proposed site for the new diversion dam at Guernsey on August 3, and the line of the proposed Goshen Park Canal on August 4 and 5. The diversion dam at Whalen and the Interstate Canal were inspected on August 6. Public hearings were held in Casper and Torrington, Wyo., and in Mitchell and Bridgeport, Nebr.

2. *Location.*—This project is located in eastern Wyoming and western Nebraska, and lies on both sides of the North Platte River. It extends along the river from Whalen, Wyo., to Bridgeport, Nebr., a length of 98 miles, and varies in width from 4 to 20 miles. Its main water supply and the greater part of the irrigable lands under the complete project lie in Wyoming. The lands in the unit now under construction lie in Nebraska. A branch line of the Chicago, Burlington & Quincy Railroad traverses the project from end to end, furnishing good railroad facilities.

3. *Description.*—The project includes a storage reservoir above the Pathfinder Dam, which is located 3 miles below the junction of the Sweetwater and North Platte Rivers; the utilization of the channel of the North Platte River for a distance of about 180 miles to conduct the stored water to the area to be irrigated; diversion dams at

several points in the lower river; and the main canals and laterals necessary to distribute the water over the lands. Of this project the completed portions are: The Pathfinder Dam (nearly finished), the diversion dam at Whalen, and the main canal, 95 miles long, heading at the Whalen Dam, known as the Interstate Canal, which with its laterals is now largely in use irrigating the greater part of the first unit on the north side of the river. The parts still to be built include a diversion dam at Guernsey, to divert water into a proposed south canal for irrigating the Goshen Park area, the extension of the Interstate Canal and its laterals, and perhaps the construction of a proposed south canal heading at the Whalen Dam, and known as the Fort Laramie Canal.

4. Before this work was undertaken by the Reclamation Service several canals had been built by private enterprise. The Whalen Falls Canal, heading in the river near Whalen, was built to irrigate about 28,000 acres, partly Carey Act lands, and the Tri-State or Farmers' Canal, heading just east of the Nebraska-Wyoming State line. Other private canals were the Mitchell and Gering Canal, Castle Rock, Hillside, Winter Creek, Bayard, and Alliance. The right of way of the Whalen Falls Canal, about 45 miles long, was purchased by the Reclamation Service and used for the Interstate Canal. The areas irrigated under the Interstate Canal include, by special agreement, the lands formerly irrigated under the canals which were absorbed by the Government and the lands lying to the eastward included between the Tri-State and the Interstate Canals.

5. *Engineering features.*—The main engineering feature of the project is the Pathfinder Dam and Reservoir. The dam is about 54 miles from Casper, Wyo., and is located in the bed of the North Platte River in a narrow gorge having granite walls. It is of the arch type, the radius of its center line being 150 feet, and is built of uncoursed cyclopean granite masonry except the two faces, which are laid in 2 and 3 foot courses. The height is 214 feet above the river bed. It is 432 feet long on top and 80 feet long on the bottom. The top width is 14 feet, providing a 10-foot roadway, and the bottom width is 90 feet. A spillway 700 feet long at the north end is under construction. This spillway is being cut in the rock abutment and will be provided with a low concrete weir. The area of the reservoir at the level of the spillway is 21,774 acres, and its capacity is 1,025,000 acre-feet.

6. It was the original intention to release all the water through the tunnel cut in the natural rock on the north side used to pass the river flow during construction. This tunnel is 481 feet long, 10 feet by 13 feet in cross section, and has a capacity of 7,000 second-feet under full head. It is closed by four sliding cast-iron gates separated by concrete piers, the tunnel being widened to maintain ample sectional area. These gates are under 180-foot head when the reservoir is full. Although this head has never been reached, the force of the water while being discharged under less head was such as to damage the tunnel lining and an additional outlet at a higher level was decided upon. This will be 60 feet higher, will be 360 feet long and 12 feet by 13 feet in cross section. Water will be admitted by six needle or balanced-pressure valves 5 feet in diameter. This tunnel is nearly completed.

7. The rock abutment of the dam on the left bank is continuous to high ground, but on the right bank the rock surface drops and the abutment is connected with the high ground by a long, flat ridge of gravel and sand in layers, the rock surface not being found at depths of 60 feet below the surface. This gravel ridge has a long gap which is lower than the spillways. To close this gap an earth dike is now being constructed. This dike is strengthened by using a concrete core wall, by the selection of impervious material for the interior, and by heavy paving on the reservoir side.

8. The Whalen Diversion Dam is a concrete overflow weir of the ogee type with a height of 26 feet at the highest place and a length of 300 feet. Head gates are provided at each end, one set of which is in use at the head of the Interstate Canal, and the other set is intended for the Fort Laramie Canal if it should be constructed.

9. The Interstate is the main canal. It has a calculated carrying capacity of 1,400 second-feet for the first 28 miles, after which the capacity is reduced. It was designed for a velocity of 2.8 feet per second, which was exceeded when the canal was put in operation, and a system of check gates was necessary throughout its entire length. Three reenforced concrete siphons of the box type were constructed to carry the canals under Rawhide, Spotted Tail, and Dry Spotted Tail Creeks.

10. The plan of irrigation comprises three districts in addition to the land formerly irrigated under private systems. A series of three reservoirs is contemplated, having capacities of 13,000, 27,000, and 90,000 acre-feet, to enable more water to be saved from the flood flow of the river.

11. *Water supply.*—This project gets its water from the North Platte River, which has a drainage area of 12,000 square miles, an average annual rainfall over the drainage basin of 20 inches, and an average run-off of 1,500,000 acre-feet. Many private canals using the waters of the North Platte River have water rights that antedate the filings of the Government and an adjudication of these rights by the State engineers of Wyoming and Nebraska has recently been made, allowing 463 second-feet in Wyoming and 4,618 second-feet in Nebraska. The Reclamation Service believes that the latter is excessive and that 3,000 second-feet would more than cover the amount of the priorities put to beneficial use. A study of the water supply has recently been made by the Chief Engineer of the Reclamation Service, and is attached hereto. From the assumptions made therein the conclusions are reached that the supply is ample for the irrigation of the Interstate unit and the Goshen Park unit, with a surplus sufficient for 30,000 acres additional, and as much more as the return seepage can supply. The assumptions seem reasonable and the board agrees with the conclusion that there will be sufficient water for the Interstate and the Goshen Park units. The acreage irrigable by the available supply is so dependent on how much water can be legally claimed by prior appropriators that these assumptions may be materially changed when the prior rights are definitely known. Large extensions of the project should not be made until all the water rights are settled by court decision.

12. *Lands.*—The average elevation of the irrigable area is 4,100 feet above sea level, the range of temperature is from 25° below zero to 100° Fahrenheit, and the average annual rainfall is 15 inches. Dry

farming is usually not successful. The lands of the project are in two main units, the Interstate and the Goshen Park units.

13. *Lands in the Interstate unit.*—The lands now under irrigation extend along the North Platte from Whalen to Bridgeport, much of the land, amounting to about 90,000 acres, west of Red Willow Creek in the lower part being irrigated by private canals. The areas to be supplied under the project are all north of the river and are divided into four sections. The first includes about 17,870 acres of land in Wyoming formerly irrigated under a private system, partly under the Carey Act, which land is now furnished with water under special agreement without charge for construction and with a fixed charge of 40 cents a year for 10 years for maintenance and operation. The next two districts, known as the first and second lateral districts, cover 36,760 acres and 34,100 acres, respectively. These areas are now largely under irrigation. The next is the third lateral district of 38,000 acres, in which the canals and laterals are now being built. The total of the Interstate Canal unit, including several small areas reserved, is 129,270 acres. Of this area 2,179 acres are under the Carey Act, 3,369 acres are school lands, 34,864 acres are privately owned, and the remainder are under the reclamation act. There are 88,716 acres ready for water, and 51,218 acres were irrigated in 1910.

14. The Interstate Canal as it flows eastward approaches a privately owned canal known as the Tri-State, and the irrigable area lying between is narrowed. At Red Willow Creek the canals come near enough together to permit the irrigation of the land lying east of this creek by an extension of either canal.

15. The principal products are alfalfa, cereals, corn, sugar beets, and potatoes. The soil is a light sandy loam and is easily drained. But little trouble from swamping is expected.

16. The value of the land under this unit before irrigation was from $5 to $25 per acre, and after irrigation from $75 to $100. From a consideration of the land values and its productiveness, the board believes that a construction charge of about $60 per acre can probably be borne. This amount is near the limit which the land can bear and with this charge the public lands will probably be slowly taken up for settlement. The farm unit is 80 acres.

17. *Lands in the Goshen Park unit.*—All the lands of this unit lie south of the river. The irrigable area is stated as about 210,000 acres. No work has been done beyond land surveys and canal locations. To irrigate this area it will be necessary to build a dam in the river above Guernsey, about 100 feet high. This dam would divert the water through a tunnel into a main canal which would skirt the highlands for a length of about 148 miles. Recent surveys show that a part of the area of this unit can be irrigated more economically by a lower canal heading in the river at the Whalen Dam. This proposed canal, known as the Fort Laramie, would supply 60,000 acres.

18. About 75 per cent of the area of this unit is public land, 5 per cent State land, and 2,500 acres are occupied under the Carey Act. In 1908 all unpatented public lands were withdrawn from entry to prevent settlement until again opened.

19. Some land on the south side of the river, amounting to about 40,000 acres, has been irrigated under private canals. Of this amount, the Mitchell and Gering Canal irrigates about 28,000 acres.

20. In general, the land is superior to that on the north side of the river, as there is less sand. When irrigated it sells at from $100 to $150 per acre. Without water it is worth only a few dollars per acre for grazing. The land of this unit, in the main, lies well for drainage, but some ditches for this purpose will probably be necessary in the lowlands near the river and occasionally elsewhere, as in Cherry Creek Valley.

21. *Cost.*—The cost of the reservoir has been $1,408,838.21 up to June 30, 1910. There has been allotted to this work $1,640,000. It will require for completion about $110,000 additional, as follows:

Completing dike	$20,000
Completing south side tunnel	75,000
Completing north tunnel lining and spillway	15,000
	110,000

This will make the total cost of the reservoir about $1,750,000.

22. The expenditures on the Interstate unit were $3,210,835.18 up to June 30, 1910. Allotments amounting to $3,495,000 have been made up to December, 1910. The estimate for completion is $1,075,000 additional, as follows:

Dam of Reservoir No. 1	$60,000
Dam of Reservoir No. 1½	35,000
Extending main canals and laterals	130,000
Dam of Reservoir No. 2	260,000
Dam of Reservoir No. 3	300,000
Canal and lateral system, Dam No. 3	260,000
Lateral system for isolated tracts	30,000
Total	1,075,000

This will make the total cost of the unit about $4,570,000. If part of the cost of the reservoir, amounting to $500,000, be added as the proportionate share of this unit the cost will be $5,070,000, which is the amount to be returned to the reclamation fund by payment of the construction charges. Construction charges were announced on this project under several public notices between 1907 and 1910. The first price set was $35 and applies to a small area, but this was found to be too low and was later changed to $45. Repayments are expected by the Reclamation Service under these notices as follows:

551 acres are to pay $35, or	$19,285
68,718 acres are to pay $45, or	3,092,310
69,269	3,111,595

There are 17,870 acres which pay no construction charge, leaving the remaining land of the project, 42,131 acres, to repay about $1,958,405, or about $46.48 per acre. Either the construction charge on this unit will have to be raised to at least $46.48 or there will be considerable loss to the reclamation fund.

23. Surveys for a high-line canal to irrigate 150,000 acres have been completed, and the estimated cost of construction is about $12,000,000. Surveys for the Fort Laramie Canal, to irrigate 60,000 acres, are not yet completed, but it is estimated that the cost will not exceed $3,000,000. This would make a total cost for the irrigation of the 210,000 acres of $15,000,000, or about $70 per acre. It is thought that under present conditions this is more than the land can bear, as it is suitable only for ordinary farm products. Moreover, it is stated

by the Reclamation Service that about 40,000 acres of this is second-class land and would cost about $20 per acre to bring it under cultivation, and that suitable provision will have to be made for drainage, estimated to cost about $3 per acre. Under present conditions, therefore, it does not seem practicable to construct a high-line canal either for the entire area or for 150,000 acres. The Fort Laramie Canal will cost $3,000,000 for 60,000 acres, or not to exceed $50 per acre. Of this 60,000 acres, 30,200 are public land subject to the reclamation act, 6,000 acres State lands, and 23,800 private lands. It is recommended that the Fort Laramie Canal be constructed. If it is found at a later date that the remaining lands in the Goshen Park unit can stand a construction charge of $70 to $80 per acre, a high-line canal can be subsequently built, or, if not, the surplus water from the Pathfinder Reservoir can be sold to the various private canals along the river that desire to make use of it should this course be authorized by law.

24. Since commencing irrigation the operation and maintenance charges have amounted to $351,306.28 up to June 30, 1910. Except for the collection of $2 per acre from 551 acres and 40 cents per acre from 17,874 acres, the cost of operation and maintenance has been added to the construction charge.

25. The cost of operation and maintenance in 1908 was $175,430.88, or an average of about $2 per acre for all the irrigable land within reach of water. This amount is high, but as additional areas are brought under the system and as the canals and laterals become seasoned this unit cost should be reduced.

26. *Comments.*—At the public hearing at Bridgeport the landowners in the vicinity expressed a desire to have the Government extend the Interstate Canal eastward to supply considerable areas east of Red Willow Creek. If the development of the Goshen Park area south of the river is determined on, such an extension would probably not be practicable, as it is doubtful whether the water supply will be sufficient for both. It would also require an increase in the carrying capacity of the Interstate Canal and some of its structures. The area in the Goshen Park unit is largely public land, and its irrigation is regarded as preferable to that of the Bridgeport extension of the Interstate unit.

27. The board believes that it is desirable to complete the Interstate unit for the full 110,000 acres of the three lateral districts, as at present proposed, that the water rights be adjudicated by court decision, and that 60,000 acres in the Goshen Park unit, under the Fort Laramie Canal, be irrigated.

28. *Summary.*—(1) The project is feasible from an engineering and economic standpoint.

(2) It is interstate in character, lying partly in Wyoming and partly in Nebraska.

(3) The area in the part of the project at present approved, the Interstate unit, is 129,270 acres, of which about 64 per cent is public land subject to the reclamation act. The area of the Goshen Park unit (not yet approved) is about 210,000 acres, of which about 75 per cent is public land subject to the reclamation act.

(4) The water supply available depends on the prior rights. There is a sufficient supply for the present Interstate unit and probably for the entire Goshen Park unit. Any considerable extension beyond the

present approved unit should not be begun until the water rights on this stream are adjudicated in the Federal courts and the rights of the Government definitely known.

(5) The total estimated cost of the Pathfinder Reservoir is $1,750,000, of which $1,408,000 has been expended. That of the Interstate unit is $5,070,000, of which $3,211,000 has been expended. The Interstate unit is about 80 per cent completed.

(6) The land in the Interstate unit can bear the construction charge of about $46.50, and that in the proposed Fort Laramie unit can bear the probable charge of $50 per acre. The large probable cost of $80 per acre for the remainder of the Goshen Park unit is believed to be in excess of what the land can bear at present.

(7) Owing to the large expenditures already made, the comparatively large amount of public land, and the interstate character of the project, the Interstate unit should be continued at an economical rate of progress until completed; the Fort Laramie unit should be undertaken, but the remainder of the Goshen Park unit should not be commenced at present. If this land should not increase in value sufficiently after the development of the Fort Laramie unit to warrant its irrigation, the surplus water should be used on other irrigable areas in order to repay the proportionate cost of the reservoir.

(8) The following allotments are recommended for the four years 1911–1914, inclusive:

From the fund	$2,185,000
From the loan	2,000,000
Total	4,185,000

Section XV.

TRUCKEE-CARSON PROJECT, NEVADA.

1. The Truckee-Carson project was visited by the board on September 27 and 28. The head works in the Carson River near Hazen and the irrigated lands in the vicinity of Fallon were visited on the former date. Churchill Valley, the lower Carson Reservoir site and the dam site for this reservoir, together with Truckee River diversion dam and the main Truckee Canal, were inspected on the latter date. On the evening of September 27 a public hearing was held in the town of Fallon.

2. *Location and description.*—The Truckee-Carson irrigation project provides for supplying water over large areas of land, at present barren, lying in the vicinity of Fallon, Hazen, and Fernley, Nev. For this purpose it is proposed to use the waters of the Truckee and Carson Rivers, which now flow into natural depressions in the bed of the primeval Lake Lahontan and disappear. The irrigating water comes mainly from snowfall on the mountains of eastern California, supplemented by rains in the drainage basin of the Truckee and Carson Rivers. The project is interstate in character, as part of the water supply and much of the storage are within the State of California, while the irrigated lands are in Nevada.

3. The project involves the diversion of a part of the natural flow of the Truckee River through a canal into the Carson River, together

with such stored water as may be conserved in Lake Tahoe. In addition to the flow from the Truckee River it is proposed to use the water of the Carson River, collecting the flow of both streams in a reservoir to be formed by a dam in the Carson below the outlet of the Truckee Canal. From this reservoir the supply will be released into the Carson River and again picked up at a diversion dam lower downstream, where the main distribution system commences. The completed work includes a diversion dam in the Truckee River, near Clarks, diverting water into the main Truckee Canal; the construction of the main Truckee Canal, 31 miles long, having a capacity of 1,200 second-feet; borings and other investigations for the Carson River storage dam and for the outlet works for Lake Tahoe; the construction of the Carson River diversion dam, about 4 miles from the lower end of the Truckee Canal; the construction of two irrigating canals, one of 1,500 second-feet capacity and the other of 450 second-feet capacity; the extension of laterals and minor ditches of the distribution system.

4. *Transportation facilities.*—The main line of the Southern Pacific Railway passes through Hazen, one of the towns of the project, and a branch line to Fallon affords transportation facilities for the greater part of the project. The most distant farm unit from a railway station will require a 15-mile haul to place its products upon railway cars.

5. *Construction features.*—The waters of the Truckee River are diverted into the main Truckee Canal by a dam about 20 miles below Reno. This dam is of concrete and is supplied with sluice gates, 16 in number for passing the river flow and 9 for controlling the flow into the canal. There is no overfall section in the river portion, the entire river passing through the sluiceways. The main Truckee Canal empties into the Carson River a short distance above the site for the storage dam to be built later. This dam will collect the waters of both the Truckee and Carson Rivers. About 4 miles below this dam site is the diversion dam for the distribution system. It is similar to the Truckee Dam, but has headworks at each end for controlling the two canals. The river flow is passed through 23 sluiceways, the dam having no overflow section. The main distributing canal lies on the right bank and has a capacity of 1,500 second-feet. The one on the other bank has a capacity of 450 second-feet. These two canals with their smaller laterals cover an area of country extending about 25 miles eastward and about 20 miles north and south. There are four tunnels on the main Truckee Canal.

6. *Water supply.*—Water is supplied from the Carson and Truckee Rivers, the combined annual run-off amounting to about 1,000,000 acre-feet. The area of the drainage basin is 3,450 square miles. Its average elevation above sea level is about 8,000 feet. The rainfall is about 25 inches. The average annual discharge from Lake Tahoe into the Truckee River for 10 years from 1900 to 1909 amounted to 317,000 acre-feet, the minimum being 112,730 acre-feet, and the maximum being 704,200 acre-feet. The average annual discharge of the Truckeet River at Vista below the town of Reno for 10 years was 865,840 acre-feet, the minimum being 391,000 acre-feet in 1900, and the maximum 1,813,000 acre-feet in 1907. The average annual discharge of the Carson River at Empire for nine years, 1901 to 1909, was 397,797 acre-feet, the maximum 703,900 in 1907, and the mini-

mum 141,650 in 1908. In order to utilize the large discharge of these rivers considerable storage capacity is necessary, and several suitable sites are available. The most important of these is Lake Tahoe, one of the sources of the Truckee River. This lake is situated at an elevation of 6,230 feet above sea level and has an area of 193 square miles. The drainage area above the lake outlet is 519 square miles, and below its outlet the river receives the drainage of about 1,000 square miles more.

7. The storage capacity of the lake between the limits of natural variation is upward of 600,000 acre-feet. By regulating the outlet this lake is relied on to furnish storage capacity for at least 200,000 acre-feet for use on the project. It is proposed to construct a storage reservoir in the lower Carson River by building a rock-fill dam. This reservoir will have a capacity of 290,000 acre-feet. Another depression in the Carson River near the town of Dayton, known as Alkali Flat, may be used for storage if later found necessary. Its capacity will be about 228,000 acre-feet.

8. On this project it may be stated that the amount of land of suitable character is far in excess of what can be supplied with water. There are about 40,000 acres of land irrigated under private canals in the near vicinity of Reno. The water for this land is taken from the summer flow of the Truckee River, and is probably a prior right to that of the Government, but it does not include any stored water. Some private land in the upper Carson Valley is also irrigated under prior rights. The water rights on the Truckee River have not been adjudicated, but it is stated that this is now in progress.

9. From the records there is apparently more water available than is necessary for the present proposed acreage of the project, which might permit some expansion, but a study of the precipitation records shows that the years of recorded discharge were years of more than usual rainfall, so that a considerable margin for safety is allowed by the Reclamation Service.

10. The adopted plan assumes a regulated flow in the Truckee River. In the absence of such regulation, either by means of Lake Tahoe or other reservoirs on the Truckee River, not more than 150,000 acres could be irrigated in an unfavorable year as 1908, the year of the minimum recorded flow.

11. Utilizing the storage capacity of Lake Tahoe and regulating the Truckee River flow both depend upon effecting some agreement with the prior claimants to the waters of this lake. The principal one of these is the Truckee River General Electric Co., which claims to have prior rights to about 400 second-feet of the flow for power. This company claims to own the outlet of the lake and desires to regulate the flow in its own interests. The company proposed last year to construct a new outlet to the lake, build the necessary controlling works, rebuild the old outlet works, and accept the responsibility for all damages in connection therewith if the Reclamation Service would pay one-half the cost of rebuilding the old works (this share amounting to about $20,000), operate the headworks at both outlets, furnish the company with 475 second-feet daily through the new outlet, and protect the company from suits after the new plant was installed. They offered to furnish water from other sources than Lake Tahoe for irrigating large areas around Reno, now being supplied partly

from Lake Tahoe by private companies. They proposed also to construct a reservoir at Washoe Lake of about 168,000 acre-feet capacity to hold the water used during the winter months for power development, which, under present conditions, is wasted. The old lake outlet would be used only to regulate the flow whenever necessary.

12. This agreement was not approved by the Secretary of the Interior. The use of Lake Tahoe for storage, while not an essential part of the project, is a very desirable one. The regulation of the flow of Truckee River, without using Lake Tahoe, could possibly be affected by storage elsewhere, but at a largely increased cost. A fuller discussion of the water supply is appended hereto.

13. *Lands.*—The amount of land under this project is 206,000 acres, to which must be added 13,000 acres which have a vested water right recognized by the Government and three or four thousand acres concerning which no agreement has been made. About 60 per cent of the project is public land. Only the first unit of 92,018 acres has been completed, of which 32,000 acres were furnished with water this year. In this unit there are 46,110 acres of public land, 45,908 acres of private land, of which 10,147 acres belong to the railroad and are now being sold in small tracts with the requirement that water be applied for under the reclamation act. There are included in the irrigated portion 4,600 acres of Piute Indian lands, for which the Indian Office pays the regular charge. The land is at an elevation of about 4,000 feet and has an average annual rainfall of 4 inches. It is worthless for cultivation unless irrigated. The duty of water is 3 feet on the land. The temperature ranges from 0° to 105° F. The farm unit is 80 acres if public land and 160 acres if in private ownership. The land lies in the bed of an old lake and has a slight slope sufficient for irrigation. Drainage has been found necessary, but where open drains are used swamping seems to be prevented. Alkali is found in some localities.

14. The soil is sandy loam, clay, and adobe loam. The crops are alfalfa, sugar beets, grains, and vegetables. A beet-sugar factory is under construction at Fallon. Land without a water right is practically valueless, but with a good water right it is often valued at over $100 per acre. Seventy-five dollars per acre would be about an average price. The public land is not being rapidly taken up, partly due to the undeveloped condition of the country. It was stated by the Truckee-Carson Farmers' Association that $50 was about the limit of construction charge that the land could bear. There is no water users' association, the agreement as to the use of water being between the Government and the individual farmer. The settlement of land under this project has been slow but has now reached a point where the adequate supply of water for greater area is not practicable without storage.

15. *Cost.*—The total expenditure under this project up to June 30, 1910, was $4,082,233.11, of which $137,000, or 3.4 per cent, was for examinations and surveys; $442,700, or 10.8 per cent, was for superintendence, engineering, and clerical services on the project; $5,668.55, or 0.14 per cent was for the supervising engineer's office, and $167,070.10, or 4.9 per cent, was for the Washington and Chicago offices, expert engineering, etc. The estimated cost of the completed project

is $7,000,000, or about $3,000,000 in addition to expenditures up to the present time. The items for this additional expenditure are:

Lake Tahoe Reservoir	$20,000
Lower Carson Reservoir Dam	1,250,000
District 5, distribution system	61,000
District 3, distribution system	94,000
District 4, distribution system	228,000
Carson Lake extension	316,000
Alkali Flat Reservoir	400,000
Pyramid Lake extension	500,000
Churchill Valley	131,000
Total	3,000,000

16. There has been allotted to this project $4,178,000 up to December 31, 1910. The construction charges were first set at $22 per acre, and 24,000 acres were taken up at this figure. Later the charge was raised to $30 and 6,000 acres were taken up. Thirteen thousand acres pay no construction charges. There are, therefore, 43,000 acres which are to return $708,000 to the reclamation fund. To return the cost to the reclamation fund, the remaining 176,000 acres will have to return $6,292,000, or an average of about $36 per acre, assuming that all the land will be disposed of at this figure and the estimates for completion are not exceeded. A later estimate for completion has been submitted by the chief engineer, dated October 29, 1910, amounting to $3,500,000, which it is thought will all be needed. On this basis the charge per acre would be about $39 to return the cost to the fund. The arrangement of charges suggested by the Reclamation Service is as follows:

First unit settled, 24,000 acres, at $22	$528,000
Second unit settled, 6,000 acres, at $30	180,000
Area to be opened before Alkali Flat Reservoir is constructed, 142,000 acres, at $35	4,970,000
Area to be opened after constructed, 34,000 acres, at $40	1,360,000
Total, per 206,000 acres	7,038,000

17. The cost of operation and maintenance in 1909 was $39,452.12, and the return was $20,920.90, leaving a deficit of $18,531.22. The charge for operation and maintenance has now been raised from 40 cents per acre per annum to 60 cents. The actual cost should be less than 60 cents when a large area is under irrigation, so that the deficit may ultimately be reduced by retaining the higher charge after the cost of operation is lowered.

18. *Comment.*—The diversion dams at both the Truckee and Carson Rivers are constructed without spillway, the river flow being passed through a series of gates. In both cases accidents have occurred, due to the blocking of the high-water flow by drifts or other causes, the river cutting around one end in one case and both ends in the other. This would indicate that the type was not particularly well adapted to the purpose for which designed. With this exception, the engineering features visited by the board seem to be well suited to the purpose for which intended.

19. *Summary.*—(1) The project is feasible in an engineering and economic sense.

(2) It is interstate in character, the water supply and storage being mainly in California and the irrigable area in Nevada.

(3) The total area involved is 206,000 acres, of which about 60 per cent is public land.

(4) The water supply is sufficient with the storage proposed.

(5) The estimated cost of completion is $7,000,000, of which $4,082,233.11 has been expended.

(6) The land can return the construction charge, which is now estimated at $35 to $40, but which may have to be increased.

(7) The project is a worthy one; is now more than 60 per cent completed, and should be continued at an economical rate of progress until finished.

(8) The following allotments are recommended for the four years 1911–1914, inclusive:

From the fund	$1,594,000
From the loan	1,193,000
	2,787,000

Section XVI.

CARLSBAD PROJECT, NEW MEXICO.

1. The board visited this project on October 15, 1910, inspecting the reservoirs McMillan and Avalon, the Dark Canyon Siphon, the river aqueduct, the distributing system, and the irrigable lands. In the evening of that day the board held a meeting with the water users' association.

2. *Location.*—This project is located on the Pecos River, in Eddy County, N. Mex. The project is traversed by a branch of the Santa Fe Railway, which gives good transportation facilities for the entire irrigable area.

3. *Purchase.*—This irrigation system was constructed by the Pecos Irrigation Co., which operated it until a flood in October, 1904, destroyed the dam at Lake Avalon. The company being unable to rebuild the dam, the people living on the project appealed to the Government, and early in 1906 the property and rights of the irrigation company were purchased for $150,000 allotted from the reclamation fund.

4. *Description.*—The Pecos River supplies the water for the lands, and since the low water discharge is insufficient for the area irrigated, two reservoirs have been constructed for storage. These reservoirs, Lakes McMillan and Avalon, with their dams and controlling works, constitute the principal engineering structures of the system. Lake McMillan is formed by an earth and rock-fill dam across the old river channel and is provided with two spillways and with concrete head gates. The head gates discharge into a canal cut in rock, which in turn discharges into the river bed a short distance below the dam. The head gates were constructed since the United States purchased the reservoir and the Reclamation Service has also reenforced the dam, reconstructed the spillways, and constructed a dike within the reservoir to prevent the stored waters from reaching the bordering bed of gypsum where a large leakage had existed. Lake Avalon is also formed by an earth and rock-fill dam across the river bed, the dam being provided with a concrete and sheet pile diaphragm or cut-off wall. The combined head gates and spillway is a concrete

structure, and there are two other spillways which spill over rock at low places in the rim of the reservoir. The dam, head gates, etc., were constructed by the Reclamation Service, the old dam having been destroyed by a flood prior to the purchase of the system by the United States.

5. The main canal of the system heads at Lake Avalon, on the east bank of the river, and about 3 miles below it is carried across the Pecos by a concrete flume or aqueduct. This flume was built prior to the purchase, but has since been extensively repaired by the United States. A main lateral, called the East Canal, takes out a short distance above the river crossing and covers the small irrigated area on the east bank. The main canal covers the lands west of the river, and after crossing the river it is called the Southern Canal. This canal crosses Dark Canyan in a reenforced concrete inverted siphon constructed by the United States. The minor structures of the distribution system are generally of wood, but where these have needed repairs by the Government they have been replaced with concrete. The main canals and laterals have been partially enlarged and improved by the United States. The main canal is designed for a maximum flow of 500 second-feet, the Southern Canal for 400, and the Eastern for 100 second-feet (the capacities of the Southern and Eastern being reduced in their lower portions). The assistant engineer in local charge, however, under date of September 14, 1910, in a report to the supervising engineer, states: "The present safe capacity of our main canal (Southern) to the siphon is 350 second-feet when the channel is reasonably clean. We have found from the experience of the past three seasons that the canal can not be expected to carry over 200 to 250 second-feet with safety for more than 10 days at a time during the hot summer, on account of the channel filling up with aquatic growth." The lateral which supplies the so-called Black River system; that is, the lands south of Black River, has been relocated since the United States took charge, the new portion being partially concrete lined, the lateral discharging its waters into the Black River Channel through a concrete drop.

6. The various engineering works done by the Reclamation Service in the improvement of the system appear to be well designed and well executed. However, the entire system prior to its purchase by the United States, as well as now, has been characterized by excessive losses by leakage, both in the reservoirs and in the ditches. The dike constructed in Lake McMillan has greatly reduced the leakage in that reservoir, but it is still large and evidently passes through the gypsum beds in the bluffs on the east side, north of the dike. A large part of this leakage, it is believed by the Reclamation Service, reenters the river above the Avalon Dam. But by far the most important and injurious leakage occurs in the distribution system, especially in certain portions of the Southern Canal and in the East Canal. The excessive leakage in the distribution system is believed to be due to the presence of gypsum in the soil, and it seems that the only certain remedy for it is the lining of the canals or a large portion of them with concrete. The comparatively clear water taken into the canals from Lake Avalon does not contain sufficient silt to seal the porous canal banks, most of the material carried by the river water being deposited in Lake McMillan. The subject of leakage is discussed further in the following paragraphs.

7. *Water supply.*—Water is obtained from the Pecos River, under two appropriations, one made in 1888 by the Pecos Irrigation Co. for approximately 75,000 to 100,000 acre-feet, and one made in 1905 by the Reclamation Service for 300,000 acre-feet. During the period of 1905–1910 the average run-off of the river at Dayton, above Lake McMillan, was 330,000 acre-feet, with a maximum of 915,000 acre-feet and a minimum of 154,000 acre-feet. The two reservoirs have an estimated aggregate storage capacity of about 34,000 acre-feet, Lake McMillan having a capacity of 29,000 acre-feet and Lake Avalon of 5,000 acre-feet. Since the hydrographs show a summer as well as a winter peak, the available storage is more valuable than on a stream with only one period of high-water run-off. A third reservoir site between lakes McMillan and Avalon has been under consideration and is described on page 277 of the Fourth Annual Report of the Reclamation Service. Doubt is there expressed as to the feasibility of constructing a reservoir at this point, owing to the presence of beds of gypsum and to questionable foundations at the proposed dam site. Pending a more complete examination, no opinion can be expressed by the board as to the feasibility or the cost of such a reservoir.

8. As stated above, the leakage losses in the system are very great. During 1909–10 measurements showed a loss of 40 to 44 per cent between the gauging station at Dayton and a station just below Lake McMillan. Much of this loss, however, was returned to the river above the Avalon Dam, so that the net loss between Dayton and the head gates of the main canal was only about 10 per cent. Taking 10 per cent as the net loss by leakage in the reservoirs, the average annual run-off at the Avalon head gates is approximately 300,000 acre-feet.

9. Taking the combined safe capacity of the two branches of the main canal at 275 second-feet, the canals in their present condition can divert in an irrigation season of nine months only about 148,000 acre-feet. The discharge in the year of minimum recorded run-off is about 140,000 acre-feet at the Avalon head gates, so that in the minimum year (with no water held over in the reservoir from previous years) the canal can receive at the Avalon head gates 140,000 acre-feet and in the average year 148,000 acre-feet. The measured losses in the distribution system in 1909 averaged 64 per cent of the diverted water. Applying this percentage to the above figures, we have for the delivery of water to the farms in the minimum year 50,000 acre-feet and in the average year 53,000 acre-feet. The lining of the main canals, as hereafter mentioned, will probably reduce the losses from all sources in the distribution system to not more than 25 per cent, and at the same time will increase the safe carrying capacity of the canals, so that, with the present storage capacity of the reservoirs, probably 90,000 to 100,000 acre-feet could be carried to the farms in the minimum year and up to 120,000 acre-feet in an average year.

10. This, however, brings up the question of the silting up of the reservoirs. The capacity of Lake McMillan, and to a lesser extent that of Lake Avalon, is being annually reduced by the accumulation of silt brought down by the river. Measurements made by the Reclamation Service in 1904 show a silting up of Lake McMillan during the preceding 10 years of 4 per cent per annum, and it seems fair to assume that the same rate will be maintained in the future, making the probable life of this reservoir about 25 years, with a material reduction of its usefulness long before that time. Without storage

not more than 70,000 to 80,000 acre-feet can be diverted in years of low run-off. Applying the 64 per cent factor of loss in the distribution system, there would reach the farms only 25,000 to 29,000 acre-feet, and applying a 25 per cent loss factor, there would reach the farms 52,000 to 60,000 acre-feet. The above figures indicate that under present conditions of canals and reservoirs sufficient water in an average year can be brought to the farms for the irrigation of 20,000 acres of land, and that even in a year of low run-off there will not be a very serious shortage; and, further, that with a complete silting up of the reservoirs, sufficient water from the perennial flow can be delivered to the farms in years of low run-off for the irrigation of 20,000 acres, provided the canals are put in such condition that the loss in the distribution system is reduced to not more than 25 per cent. In other words, the area which can be irrigated from the system with storage capacity and unlined canals does not differ materially from that which can be irrigated through lined canals from the perennial flow without storage. It does not seem advisable, therefore, that any increase be made in the irrigable area unless provision is made both for additional storage and for reduction of losses in the distribution system.

11. *Lands.*—In this project, as outlined and approved, there is a total irrigable area of 20,047 acres, all of which is private land except 20 acres (which has been taken up under the terms of the reclamation act). All of the private land had water rights from the appropriation of 1888 and was included in the project because it had these rights. Not all of this area has applied for water, but about 14,000 acres are now under irrigation, and it is expected by the local reclamation officers that at least 16,000 acres will be under irrigation next year. The entire 20,047 acres are, of course, under agreement to apply for water, and in the meantime the annual charges for operation and maintenance are being accumulated against them.

12. The average elevation of the irrigable area above sea level is about 3,100 feet and the range of temperature is from 0° to 110° F. The soil is of good quality and usually quite deep on most of the project. In other parts there are from 2 to 3 feet of soil over gypsum, and this also is considered good land. Where the gypsum, however, comes more nearly to the surface the land is of little value. There is a considerable area of such land within reach of water, but it is not counted as part of the irrigable area. The average annual rainfall on the irrigable area is 15 inches, but farming can not be practiced successfully without irrigation. The duty of water is based on 3 acre-feet of water per acre per year, but it is not believed that crops will suffer if, in occasional years, only 2½ acre-feet of water is supplied. The leakage in the distribution system referred to above has interfered during the past season with full supply of water to the lands at the time it was desired, and this leakage is injuring the system in another way—that is, by the swamping of lands near them. It is stated that before the destruction of the old Avalon Dam about 3,000 acres of irrigable land had been injured by seepage. The discontinuance of irrigation resulted in the lowering of the ground water level in the swamped land; but the seepage from the canals is again injuring this land, and if this seepage is not materially reduced the area of swamped lands will become as large or larger than before. The prevention of this excessive leakage is, therefore, one of the most important reasons for lining the main canals.

13. The growing season at Carlsbad is long and there is a wide diversification of crops. Among the best paying crops are alfalfa, cotton, grain, vegetables, and, probably, peaches. From statements made to the board as to the average net receipts per acre from such crops it seems to be quite certain that the land will readily bear the announced building charge of $31 per acre, as well as an additional assessment of $12 to $15 per acre to cover the estimated cost of improving the main canals by partially lining them with concrete. Statements from local sources indicate that lands not in reach of water are worth about $5 per acre; while lands having water for full irrigation are worth from $50 to $150 per acre.

14. *Proposed extension and improvement.*—The outlined project is stated to be 99.8 per cent completed. The area of good quality land which can be reached by the present distribution system is, however, considerably in excess of the 20,047 acres included in the project, and, if the water supply justified, a considerable additional area could be brought under water. It has been proposed by the water users' association that the present distribution system be improved by lining the main canals where necessary, thus greatly reducing the leakage and benefiting the present irrigable lands by eliminating the swamping and by preventing a shortage of water when the demand is at the maximum, and at the same time securing a sufficient saving of diverted water to provide for the irrigation of an additional 5,000 acres of land. The association has proposed further that the entire cost of this improvement, which is estimated by the project engineer at $250,000, be charged to the 5,000 acres to be brought in. The board believes that, should the water supply justify, the 5,000 acres so brought in would be benefited sufficiently to enable them to return a construction charge of $50 per acre. As stated above, however, the uncertainty as to the effect the silting in Lake McMillan will have on the amount of water which can be made available for use during the irrigation season and the uncertainty as to whether the third or intermediate reservoir is feasible, renders it very doubtful if more than 20,000 acres can be given full irrigation after silting in Lake McMillan has left it with little storage capacity, even though the losses in the distribution system have been reduced to 25 per cent.

15. The lining of the main canals with concrete, wherever found necessary, is nevertheless regarded by the board as a necessary improvement both to conserve water and to prevent the swamping of land. It has been suggested that this improvement be gradually made, taking up first the lining of those places where the leakage is most serious and that it be paid for by assessments against the 20,047 acres now in the project, the assessments to be included in collections for operation and maintenance and to be so distributed in the different years that the annual aggregate amount to be paid be not too burdensome. This plan would benefit the present irrigated lands at the expense of such lands and would require no advance of money from the reclamation fund, since the improvement could be carried on only so fast as the actual collections of the assessment would justify. By the water users thus assessing themselves, say at the rate of $2 per acre per year, they would secure, in six or seven years, freedom from water logging of lands by seepage from the canals, a more certain supply of water at the farms, and possibly a surplus of avail-

able water which could probably be disposed of on a water-rental basis to lands now in reach of the present distribution system or extensions thereof, but not now included in the project, the returns from such rental partially offsetting the assessments for the improvement. The cutting off of the seepage losses would keep pace with the gradual loss of storage capacity in McMillan Reservoir and would possibly more than offset this. At the end of six or seven years much more would be known as to the available storage capacities of the system, and if conditions then justified an additional area of irrigable land could be permanently taken into the project. The board regards with favor this method of carrying on the work of lining the canals. It does not regard it as advisable that an allotment be made for this purpose from the reclamation fund.

16. *Returns to the reclamation fund.*—The project was formerly opened by public notice, dated December 17, 1907, the building charge being announced at $31 per acre, and the charge for operation and maintenance at $0.75 per acre per year. The latter subsequently (public notice dated June 2, 1909) being raised to $1.35 per acre per year. There has been allotted to this project a total of $705,000, which is practically all expended. Of this $604,738.62, or, say $605,000, was charged to construction and the remainder to operation and maintenance. Taking the irrigable area at 20,000 acres, the expected return from the building charge of $31 per acre is $620,000. There has been charged to operation and maintenance about $100,000, for which there has been collected (or accrued) to June 30, 1910, about $33,000. The excess of operation and maintenance over collections therefor is due principally to the betterments paid for under that head. The construction charge already having been announced, betterments such as the dike in Lake McMillan, were made under an agreement with the water users' association, the substance of which being that the cost of such betterments should not all be included in the collection for a single year for operation and maintenance, but should be held as an open account and gradually returned at the rate of $0.35 per acre per year. This deficit should, under the agreement be returned in about nine years. The above figures indicate that this project will return its entire cost to the reclamation fund.

17. *Summary.*—(1) This project, both as to lands and water supply, lies entirely within the Territory of New Mexico.

(2) Out of the 20,047 acres of irrigable land all is under private ownership except 20 acres.

(3) The various engineering works done by the Reclamation Service in the improvement of this irrigation system appear to be well designed and well executed.

(4) The system is in good condition, except for the excessive leakage in the reservoirs and the distribution system, and for the reduction in carrying capacity of the canals caused by the aquatic growths, conditions which are practically the same as before the purchase of the system.

(5) The board believes that, under present conditions, in a year of average run-off sufficient water can be carried to the farms for the 20,047 acres now in the project, and that even in a year of low run-off there will not be an injurious shortage; and further that with

a complete silting up of the reservoirs there will be sufficient water from the perennial flow to irrigate 20,047 acres, provided the losses in the distribution system are reduced by lining the canals, to approximately 25 per cent.

(6) The estimated final cost of this project is about $605,000, all of which had been expended prior to June 30, 1910.

(7) This project can reasonably be expected to return its cost to the Reclamation Fund.

(8) In the opinion of the board it is not advisable to take an additional acreage into the project unless provision is made both for reduction of losses in the distribution system and for additional storage.

(9) No opinion can be expressed as to the feasibility of obtaining additional storage until a more complete examination is made by the Reclamation Service of the " Third " reservoir site.

(10) The board believes that the lining of the main canals with concrete, to reduce the leakage, is a necessary improvement; that such work should be paid for by assessments by the water users' association on the lands now in the project; and that no allotment should be made for this purpose from reclamation funds.

Section XVII.

HONDO PROJECT, NEW MEXICO.

1. The board visited this project on October 16, 1910, inspecting the reservoir, the inlet canal and controlling works, the outlet canal and controlling works, a portion of the irrigable area and of the distribution system, as well as the Hondo River in the vicinity of the point where the proposed canal is designed to take out from the river. The board also examined the area east of Roswell, irrigated by artesian water. During the day and in the evening, at a meeting in the rooms of the Commercial Club, informal discussions were held with local people interested in the project.

2. *Location.*—This project is located on the lower part of the Hondo River, in Chaves County, N. Mex., the only town in the project being Roswell. A branch of the Santa Fe Railway passes through Roswell, giving transportation facilities to this project, the most distant farm unit of which is less than 12 miles from Roswell.

3. *Description.*—In the development of this system the Hondo River is the source of the water supply. The river in this portion of its channel has no low-water flow, and a reservoir was therefore necessary for the storage of the flood waters of the stream. This reservoir is formed by six earth dikes, having an aggregate length of 16,500 feet, constructed to close the low places in the rim of a natural depression. A short earth-fill diversion dam with rock-protected slopes diverts the water from the Hondo into the inlet canal, which is provided with concrete spillways, a silt-catch basin, and sluicing gates for the removal of silt. This canal discharges into the reservoir through a rock cut. There are two spillways for the reservoir, both being the natural rock at low places in the rim. The water is taken out of the reservoir through the outlet canal, which connects the low places in the reservoir with the old river channel, the water passing

through the main dike or dam in two 36-inch cast-iron pipes embedded in concrete, suitable valves and operating devices being provided. From the river the water is diverted by three short diversion dams into the four main canals of the system. The minor structures, such as drops and turn-outs, are of concrete. The canals and laterals are of the usual type of unlined earth ditches. The reservoir embankments, the outlet and inlet canals, and the earth-fill diversion dam appear to be well designed and well constructed. The soil about the reservoir is in places impregnated with gypsum, the presence of which within the reservoir has caused considerable expense in the repair and maintenance of the bottom to keep it water tight. This expense is not yet ended, as so far there has not been sufficient water in the reservoir to thoroughly test the bottom. The efficiency of the structures designed to keep silt out of the reservoir and to remove it from the inlet canal has not been tested because of the very limited amount of flood water during the two seasons since the completion of the reservoir, and the board does not believe it to be certain that these devices will be successful in accomplishing their object. While the diversion dam and the minor structures of concrete do not show the economy of design ordinarily noted on such works of the Reclamation Service, they will undoubtedly serve their purpose.

4. *Water supply.*—The drainage area of the Hondo River above the reservoir is about 1,000 square miles, and much of it is said to be rough and broken, with a correspondingly large run-off. The available records of rainfall on the watershed are given in the following table:

Years.	Fort Stanton, N. Mex.	Roswell, N. Mex.
	Inches.	*Inches.*
1856	16.8	.....
1857	28.7	.....
1858	18.8	.....
1859	23.8	.....
1860	13.7	.....
1869	22.8	.....
1870	18.0	.....
1871	20.5	.....
1872	23.8	.....
1882	6.8	.....
1884	23.5	.....
1885	12.6	.....
1886	20.2	.....
1887	16.8	.....
1888	18.0	.....
1889	14.5	.....
1890	11.9	.....
1891	14.7	.....
1892	11.3	.....
1893	15.8	.....
1894	12.1	.....
1895	14.5	16.3
1896	.....	13.2
1897	16.4	15.3
1898	22.5	21.0
1899	14.4	16.6
1900	17.8	19.8
1901	18.1	17.9
1902	9.9	16.6
1903	9.5	8.0
1904	16.9	14.1
1905	22.6	19.3
1906	17.0	15.3
1907	17.2	13.5
1908	13.8	9.6
1909	11.7	7.7

NOTE.—No records available for missing years.

Fort Stanton is on the Bonito Branch of the Hondo, at an elevation above sea level of about 6,000 feet, and Roswell is below the reservoir near the mouth of the Hondo, at an elevation above sea level of about 3,700 feet. It is not known to what extent these records are representative of the rainfall throughout the Hondo watershed.

5. Prior to 1869 the Hondo River had a perennial flow through its entire course, but due to increased use for agricultural purposes in its upper reaches the lower portion of the Hondo became dry except during floods. This was the situation at the time the project was first investigated by the Reclamation Service. No discharge measurements had been made and the only evidence as to the amount of run-off lay in the frequent flooding of the town of Roswell. The natural channel at this point is hardly more than 20 feet wide and from 6 to 10 feet deep, and its carrying capacity is small.

6. Based on this evidence, the record of rainfall at Fort Stanton, and the character of the topography of the watershed, the project was undertaken in 1904, and the reservoir constructed with an available capacity of 40,000 acre-feet. It was completed in August, 1906. Since that date the run-off has not been sufficient to permit the storage of any water. In 1907 a small quantity was furnished from the flood flow of the river directly to a small portion of the land under the project. In 1908, 1,753 acre-feet were so furnished; in 1909, 731 acre-feet; and in 1910 a small amount.

7. With the purchase of 800 acres of land for reservoir purposes, the water rights appurtenant thereto were acquired, the date of the appropriation being 1887 or 1888. In January, 1906, an additional filing for 80,000 acre-feet was made by the Reclamation Service. There are numerous other water rights on this stream, most of which antedate those of the Reclamation Service. Such of these rights as pertain to land below the storage reservoir and within the limits of the project are to be merged with those of the United States, under the terms of the contracts between the United States and the Hondo Water Users' Association. Much of the flow of this river is used in its upper reaches under appropriations which also antedate those of the United States. No adjudication of the water rights on the Hondo or its tributaries has yet been made, though suit with this object in view is now pending in the Territorial courts.

8. At a point in the river about where the Diamond "A" gauging station was located there was observed by the board a considerable flow of water which was lost by seepage into the bed of the river, the bed at the diversion dam being dry. This loss was measured by the Territorial engineer and found to be, for the 12 months from May 1, 1908, to April 30, 1909, about 10,000 acre-feet, equivalent to an average discharge of about 14 second-feet. In his report on this subject he states that this loss is at times as much as 33 second-feet. The suggestion to divert this water into the reservoir through a concrete-lined canal will be considered under the head of "Betterments." In 1909 an effort was made by the residents of the upper valley to file on this water which is now going to waste. This attempted appropriation has been temporarily held up by the Territorial engineer, but it is urged by the Hondo Water Users' Association that unless steps be taken by the United States to use it beneficially it will be awarded to others.

9. The data at hand as to the water supply for this project, as set forth above, is not sufficient to justify the board in drawing any conclusions as to whether or not, under normal conditions, there will be a sufficient supply of water for the irrigation of the 10,000 acres in the project.

10. There are included in this project 10,000 acres, of which all is under private ownership except 240 acres of public land. In the Eighth Annual Report of the Reclamation Service it is stated "Temporary water-rental contracts were entered into with individuals during 1908, and about 1,200 acres were served with an inadequate supply of water. No water has been available in 1909. Some alfalfa, head grains, and fruit trees are under cultivation and are being maintained with great trouble." It is understood that the conditions in 1910 are about the same as in 1909.

11. The average elevation of the irrigable area above sea level is about 3,750 feet, and the range of temperature is from 0° to 100° F. The average rainfall on the lands is about 16 inches, but this is not distributed throughout the year so as to permit successful dry farming. The duty of water is figured at 2½ feet delivered on the farm. The lands under this project are of good quality, the soil being deep and varying from sandy loam to adobe. The land requires very little work to put it under irrigation and cultivation, and it is believed that the slopes are such as to insure good drainage. The growing season is long. The principal crops grown in this vicinity are alfalfa, fruits, head grains, etc. The returns from the irrigated lands in the artesian district adjoining Roswell on the east, as well as the values of these lands, indicate that with a full supply of water the lands in the Hondo project would readily bear a construction charge of $44 to $50 per acre.

12. *Cost.*—There has been allotted to this project to date $359,000, of which over $349,000 was expended prior to June 30, 1910. Of this amount, $33,347.72, or 10 per cent, was for field engineering and superintendence; $3,900.52, or 1 per cent, for clerical services on the project; and $12,280.55, or 3.6 per cent, for the Washington and Chicago offices, expert engineering, etc. The balance, it is expected, will be exhausted by the end of 1910. About $2,900 has been collected from the sale of such water as was available, so that by the end of the year the net investment of the United States will be approximately $356,000. The project was completed by May, 1907, but, because of the lack of water, it has not yet been declared open and no building charge has been announced. The betterments referred to below are roughly estimated to cost $60,000. Adding this to the net cost, we have $416,000, to which should be added, say, $24,000, to provide for operation and maintenance until the project is self-supporting, and for contingencies. The total of these is $440,000, which for 10,000 acres will give a building charge of $44 per acre.

13. *Proposed betterments.*—It has been suggested that an impervious canal of approximately 60 second-feet capacity be constructed connecting the inlet canal with the Hondo at or near the Diamond "A" gauging station. Such a canal would be about 12 miles long, and a short diversion dam in the Hondo would also be required to divert water into it. The cost of this betterment has been roughly estimated by the project engineer at $60,000. The purpose of this canal is to bring down to the reservoir the water now lost by seepage into the

bed of the Hondo which, in the 12 months beginning with May, 1908, was found to be about 10,000 acre-feet. If the adjudication by the courts indicates that this amount of water can be obtained annually, the water so saved and brought down to the project lands will probably serve to keep alive and render more or less productive the alfalfa fields and orchards now on the project lands. If this water be sold to these lands at a fixed price per acre-foot, it will produce a return probably more than sufficient to pay for the maintenance of the system while it is awaiting a formal opening. In case the rainfall in the watershed of the Hondo shall increase sufficiently to justify the opening of the project, this canal will still be useful, as the water saved by it will about make up for evaporation loss in the reservoir, and as this water, in years of shortage, may be sufficient to keep alive the larger acreage of perennial crops which may then be on the project. The merit of the suggested betterment seems to rest chiefly, therefore, on whether approximately 8,000 to 10,000 acre-feet can be secured after all prior rights (as determined by the adjudication now under way) are satisfied. The board considers favorably such a betterment under the conditions cited as to amount of water expected to be saved and as to cost. An argument against this expenditure is, that should it be necessary to abandon the project altogether the amount of money lost to the United States will be increased by about $60,000. For this reason the board believes that as a prior condition to the allotment of money for this work the landowners be required to make an additional contract with the Government to insure the return of this expenditure whether or not conditions justify the opening of the project as originally outlined. If the landowners prefer to construct this canal at their own expense rather than to enter into the additional contract with the Government, the board believes that they should be permitted to do so, under such conditions as will protect the rights of the entire body of owners under the project as well as those of the United States.

14. *Summary.*—(1) This project, both as to the lands and the water supply, lies entirely within the Territory of New Mexico.

(2) All of the irrigable land in the project is private land except 2.4 per cent.

(3) In general the engineering structures appear to be well designed and well executed, but the board does not believe it to be certain that the devices for handling the silt problem will be successful.

(4) At the time the project was started the data as to water supply appear to have been insufficient to warrant the undertaking, and such data are not now sufficient to justify the board in drawing conclusions as to whether or not under normal rainfall conditions there will be sufficient water for the irrigation of the 10,000 acres in the project.

(5) The returns from the irrigated lands in the artesian district adjoining this project, as well as the values of these lands, indicate that with a full water supply the lands in the Hondo project would readily bear a construction charge of $44 to $50 per acre.

(6) The construction of a small concrete-lined canal from the inlet canal to the river at a point above the Diamond "A" gauging station to save the water now lost by seepage is regarded by the board as a desirable betterment, provided further examination, after the water rights have been adjudicated by the courts, indicates that

approximately 10,000 acre-feet can be saved thereby for use on the lands of the project and that the cost of this additional work will not exceed $60,000 to $70,000. Under such conditions it is recommended by the board that an allotment be made for this work, provided the landowners will enter into an additional contract with the United States to insure the return of such an allotment independently of the success or nonsuccess of the project as originally outlined.

(7) Pending the court adjudication, should the landowners prefer to make this improvement at their own expense, the board recommends that they be permitted to do so under such conditions as will protect the rights of the entire body of landowners as well as those of the United States.

(8) The estimated final cost of this project is about $359,000, of which over $349,000 was expended prior to June 30, 1910.

Section XVIII.

RIO GRANDE PROJECT, NEW MEXICO-TEXAS.

1. This project was inspected by the board on October 11, 12, and 13, public hearings being held at El Paso, Tex., and Las Cruces, N. Mex.

2. *Location.*—Part of the project lies in New Mexico and part in Texas; and it includes the furnishing of water to the Republic of Mexico. It is therefore international as well as interstate in character.

3. Transportation facilities are afforded by the Atchison, Topeka & Santa Fe, El Paso & Southwestern, Southern Pacific, and Texas & Pacific Railroads. The scope of the project and its relation to the above railroads is shown on the accompanying map.

4. *Description.*—The project as outlined consists of a storage reservoir on the Rio Grande, about 9 miles from the town of Engle, with a capacity of 2,368,490 acre-feet, sufficient to fully control the run-off of the river at this point; four diversion dams lower down in the river; and four distributing systems heading at these dams and covering the irrigable lands in the United States.

5. The international features of the project are covered by a treaty, dated May 21, 1906, between the United States and Mexico, which provides that upon completion of the project the United States shall deliver to Mexico a total of 60,000 acre-feet of water annually in the bed of the Rio Grande at the headworks of the existing Mexican canal above the city of Juarez, Mex. In return the Mexican Government waives all of its claims to water in the Rio Grande above the town of Fort Quitman, Tex., and all claims for past damages from shortage of water. In 1907 Congress appropriated $1,000,000 toward the construction of the necessary storage dam and provided that—

> The balance of the cost of said irrigation project over and above the amount herein appropriated shall be allotted by the Secretary of the Interior as may be needed and as may be available from time to time from the reclamation fund, etc.

6. One of the diversion dams, that at the head of the Mesilla Valley, in New Mexico, has been built, together with 6 miles of main

canal leading from it. The dam is of rubble concrete, partly reenforced, and rests on a pile foundation. Its length is 600 feet and its height 9 feet, as measured from a point 4 feet below the original stream bed. The top which is 3 feet and the bottom width 30 feet, of which 24 feet is in the form of an apron, 2 feet thick. It is built on a bed of gravel, 16 to 20 feet thick, underlaid with clay. Two rows of triple-lap sheet piling, one row under each toe, prevents underflow. Concrete headworks at the left abutment, founded on rock, provide for the diversion of 500 second-feet. This dam is well built and suitable for the purpose intended.

7. Reservoir sites on this river were first surveyed in 1889, and since that date a number of different projects for storing and utilizing its flood waters have been advocated. Comparative studies of these projects, supplemented by additional surveys and investigations in 1903 and 1904, led to the selection of the Engle site as offering the greatest number of advantages and the fewest disadvantages. It is the only proposed reservoir large enough to utilize the entire flow of the drainage basin; it does not submerge any railroads nor any area of valuable valley lands; it is sufficiently low in the basin to intercept practically all the water and sufficiently high to command enough land for the available water supply.

8. The reservoir is to be formed by the construction of a masonry dam near Elephant Butte. This reservoir when full will be 40 miles long and have an area of 40,000 acres. Ownership of the area to be submerged has been acquired by condemnation and a construction railroad is being graded from Engle to the dam site, but no work of a permanent character has been done on the dam. A limited number of borings have been made at the dam site and preliminary designs of the dam prepared. These designs contemplate a straight concrete dam of gravity section faced with concrete blocks. The dam will be 1,255 feet long on top, 260 feet high above foundation, 206 feet high above river bed, 200 feet thick at maximum point, and will have a maximum pressure on foundations of 16.27 tons per square foot.

9. The dam is to be founded on sandstone rock, which preliminary borings in 1903 and 1904 showed at depths below the surface ranging from 50 to 65 feet. The abutments are of similar material more or less shattered and seamy on the surface. Additional wash and diamond drill borings are now being made to develop more exactly the contour of the rock foundations.

10. From the data available the proposed dam appears to be feasible, but further information is desirable concerning the foundations and abutments, the crushing strength of the sandstone, and the crushing strength of concrete made from the available materials.

11. The large capacity of the reservoir is intended mainly for the solution of the sediment problem, which is a difficult and serious obstacle to the utilization of the flood waters of this river. Observations of the silt-bearing capacity of this stream have been made since 1897 under the supervision of the United States consulting engineer of the International Boundary Commission. For the first part of this period, 1897–1904, the observations indicated that silt formed 1.8 per cent of the total discharge. Since 1904, the measurements show an average of 1.2 per cent.

12. If the higher percentage is assumed, together with an average annual run-off of 1,000,000 acre-feet, the reservoir capacity would diminish at the rate of 18,000 acre-feet a year. Sixty-five years would, therefore, be required to half fill the reservoir and until that condition exists its usefulness for storage and regulation would still be large.

13. By the construction of silt barriers above the reservoir, either in the main river or in some of the principal silt-bearing tributaries, the life of the reservoir can be materially extended, but the need for such auxiliary structures is so remote that the burden of erecting them can equitably be left to the future.

14. *Water supply.*—The drainage area above the reservoir dam is 30,000 square miles and the average annual run-off at this point since 1895 has been about 1,000,000 acre-feet. The run-off is very irregular, varying from a minimum of 200,000 acre-feet in 1902 to a maximum of over 2,000,000 in 1897. The flow during the year is also very irregular, varying from no flow to a maximum of 30,000 second-feet. Storage and regulation are therefore essential features of the project.

15. The Reclamation Service has prepared service tables for the proposed Engle Reservoir covering the period 1895 to 1909. One of these tables is based upon an annual use of water for irrigation of 750,000 acre-feet after 1896 and an annual evaporation on the reservoir of 7.07 feet. The other is based upon an annual use of water for irrigation of 800,000 acre-feet after 1896 and evaporation on the reservoir of 5 feet. Both tables are based upon a deposit of silt in the reservoir equal to 1.8 per cent of the inflow and upon a variable demand for water during the irrigation season. The contents of the reservoir at the beginning of each month of the period is increased by the inflow and decreased by use, evaporation, and overflow for the month to get the contents at the beginning of the next month. The tabulated results show that with an assumed use of 750,000 acre-feet and an evaporation loss of 7.07 feet there would have been a deficiency in 1903 of 5 per cent, and in 1904 of 18 per cent, with no deficiencies in other years. With an assumed use of 800,000 acre-feet and an evaporation loss of 5 feet there would have been a deficiency in 1903 of less than 8 per cent, and in 1904 of 25 per cent, with no deficiencies in other years.

16. As recent observations in the Imperial Valley, Cal., and in Salt River Valley, Ariz., indicate that the evaporation loss on large bodies of water in this part of the United States is more nearly 5 feet than 7 feet, there seems to be an assured annual supply of 750,000 to 800,000 acre-feet provided the flow of the river at this point is not decreased by an increased use above this point and provided the existing rights below the reservoir are merged with those of the United States. The latter condition has practically been met, as the owners of nearly all the land now being served by private ditches have signified their assent by joining the water users' association.

17. To guard against increased use of water in the upper reaches of the Rio Grande, particularly in the San Luis Valley, Colo., the Department of the Interior has prohibited the acquisition by residents of this valley of reservoir sites upon Federal lands. Without such reservoirs to store flood waters no increased use is probable. The question

of limiting the use of Rio Grande water in Colorado in the manner above indicated will be referred to hereafter.

18. The duty of water is 3 acre-feet per acre measured at the farm. Allowing for a 20 per cent loss in the distribution system, there will be required for diversion to lands in the United States 581,250 acre-feet, to which must be added the 60,000 acre-feet required by treaty to be delivered to Mexico, making a total of 641,250 acre-feet. In addition to losses in the distribution system there will be losses in transit between the reservoir and the diversion dams. With a 20 per cent allowance for this loss, approximately 800,000 acre-feet of reservoir water would be required. The losses in transit, however, will be partly offset by the return seepage in upper parts of the valley, which will be available for diversion lower down. It, therefore, appears that the available supply accords closely with the demand.

19. *Lands.*—The average elevation of the irrigable area is 3,700 feet above sea level and the average annual rainfall 9½ inches. The total area in the project is 155,000 acres, of which approximately 12,000 acres are public land subject to the reclamation act; 110,000 acres lie in New Mexico, and 45,000 acres in Texas. All of the public land is in New Mexico.

20. The soil is good, and is described as sandy loam and fertile alluvium. Much of it has been irrigated in the past, but during the last 20 years the area cultivated has gradually decreased from about 100,000 acres to 50,000 acres with an insufficient water supply for even the present area. This decrease in acreage is due to decrease in the flow of the river and this in turn is alleged to be due to increased use of the waters of the Rio Grande in San Luis Valley, Colo.

21. Three of the private ditches in the Mesilla Valley are receiving water through the Leasburg Canal constructed by the Reclamation Service. Pending completion of the project the deliveries are made on a rental basis. The Franklin Canal, serving land below El Paso, is owned by an English company, but the El Paso Water Users' Association holds it under lease and has an option for its purchase.

22. These canals, as well as other private canals in the area covered by the Rio Grande project, are to be absorbed and become a part of the project, the existing water rights being merged with those of the United States.

23. The principal products are alfalfa, corn, wheat, melons, fruits, and vegetables, and with sufficient water it is claimed that net returns of $50 an acre can be secured.

24. Before the Rio Grande project was considered, unimproved agricultural land in this valley had an average value of from $5 to $10 per acre, and improved land $35 to $50 per acre. With an assured water supply it is estimated that the value of the land will be $200 to $300 per acre.

25. *Cost.*—The expenditures on this project to June 30, 1910, were:

General project (including plant)	$463,960
Leasburg unit	201,079
	665,039

26. The estimated cost of completion is $9,000,000. This estimate, as presented to the board, is very general in its terms, the details of the project not having been determined upon. It includes $1,000,000 for electrical development, but until more detailed surveys are made

and the amount of power that can be developed at different points is determined no opinion can be expressed as to the advisability of this part of the expenditure.

27. Assuming the total cost at $9,665,000, and deducting $1,000,000, the amount appropriated by the United States to cover the cost of meeting its treaty obligations with Mexico, there will remain $8,665,000 to be paid by the owners of the 155,000 acres in the project, equivalent to $56 an acre. The character of the soil and its productiveness when irrigated are such that the land can bear this charge.

28. Two water users' associations have been organized on this project, and the par value of the stock in each is $40 per acre. Provision is made in the by-laws for increasing the par value of the stock if the building charge per acre exceeds this amount. As this seems probable and as the liability of the land for an amount greater than the par value of the stock is questionable, the water users' associations should be required to increase the par value of the stock to not less than $56.

29. *Comments.*—As stated under the heading "Water supply," it has been thought necessary in the interest of this project to interfere with the extension of irrigation in the San Luis Valley, Colo., near the source of the Rio Grande, by prohibiting the acquisition, under the laws of the United States, of reservoir sites upon Federal lands in this valley.

30. The people of San Luis Valley regard this as an unnecessary interference with their rights and oppose the construction of the Engle Reservoir on the following grounds:

(1) That a large part of the land to be reclaimed lies in Texas, in which State the Federal Government owns no land; that Congress is without authority to provide for the reclamation of any land within a State in which the Government does not own any land, and that, therefore, the act of Congress extending the reclamation act to Texas is unconstitutional.

(2) That the proposed Engle Reservoir is needlessly large and that its construction involves a waste of public funds.

(3) That it is not an economic proposition in view of the rate at which it will be filled with sediment.

(4) That the irrigable land under consideration can be reclaimed by the maintenance of a uniform flow in the Rio Grande to be secured by the construction of several small and comparatively inexpensive reservoirs at different points along the river.

(5) That the most effectual way of securing uniformity in flow is by encouraging irrigation in the upper reaches.

31. In reference to these objections it may be said:

(1) That this project is international as well as interstate in character; that it has been specifically sanctioned by Congress; and that there is no reason to assume that Congress is without power to fulfill its treaty obligations, even though incidental benefits are conferred upon land in private ownership.

(2) That a study of the duty of the reservoir, assuming it to have been built in 1895, shows it to be no larger than is necessary for the irrigation of the lands within the project.

(3) That the rate of silting up will probably be less than that assumed by the Reclamation Service, and that by the construction of silt barriers above the reservoir its life can be materially extended.

(4) That an equivalent amount of storage divided among a number of small reservoirs would probably cost more per acre-foot than storage in Engle Reservoir.

(5) That while irrigation does tend toward uniformity of flow, experience in a number of irrigated regions, indicates that the return flow is only a small percentage of the amount diverted.

32. The flow of the Rio Grande at El Paso during the irrigating season has gradually decreased during the past 20 years, with a corresponding reduction in the acreage irrigated in this vicinity from this source, while the acreage irrigated in the San Luis Valley from the Rio Grande has greatly increased. The proposed project will restore and improve former conditions in the valleys to be reclaimed without damage to areas now being irrigated in San Luis Valley, though to insure its success large additional developments in the San Luis Valley are prevented. The board does not believe that the objections of the San Luis Valley people are of sufficient weight to warrant a change in the plans of the Rio Grande project.

33. *Summary.*—(1) The Rio Grande project involves the reclamation of 155,000 acres of land in the United States, of which 12,000 acres are public land, subject to the reclamation act.

(2) It provides for delivering water to Mexico in fulfillment of treaty obligations.

(3) It is interstate as well as international in character.

(4) The water supply is sufficient for the purpose.

(5) The estimated total cost is $9,665,000, of which $665,000 has been expended.

(6) It is feasible from an engineering and economic standpoint, and the land can bear the probable construction charge of $56.

(7) The water users' association should be required to increase the par value of its stock to not less than $56.

(8) Assuming such action by the water users' association, the project should be completed.

(9) The following allotments are recommended for the four years, 1911–1914, inclusive:

From the fund	$1,855,000
From the loan	4,500,000
Total	6,355,000

Section XIX.

MISSOURI RIVER PUMPING UNITS, NORTH DAKOTA.

1. The board visited these projects on August 17, 1910, inspecting the power station, the coal mine, the floating and secondary pumping plants, the settling basins, and a large part of the ditches and the irrigible lands. Public hearings were held on the same day at Buford and at Williston.

2. *Unity of projects.*—These projects are carried in the reclamation records as two separate projects under the names of the Buford-Trenton and the Williston, and the water users under each of these units are organized into a water users' association, with each of which the Reclamation Service has made a contract for the irrigation of lands

owned by the stockholders. Physically, however, these projects constitute two units of a single project, and in this report are so considered.

3. *Location.*—This project is located on the north bank of the Missouri River, just below the mouth of the Yellowstone, and lies entirely within Williams County, N. Dak. The Great Northern Railway runs through the project and gives it good transportation facilities, the principal stations being Williston, Buford, and Trenton.

4. *Description.*—This is a pumping project, the water being lifted by electrically operated pumps. For the generation of electricity there is a central power plant near Williston from which high-voltage transmission lines carry the current to the several pumping plants. The present power installation is sufficient only for such pumps as are now installed, but additions can readily be made to the power plant when required. The power house is located at the mine from which fuel is obtained. The fuel is lignite, which is burned in special furnaces. The United States owns the mine, the cost of the fuel to the project being only the cost of mining.

5. The Buford-Trenton unit in its present condition includes a pumping plant mounted on a barge in the Missouri River, forcing water through steel pipes into a settling basin located near Buford. On the barge are mounted four electrically driven pumps having a combined capacity of 120 second-feet for a 30-foot lift. At the settling basin there is located a secondary pumping plant in which are installed four electric pumps having a combined capacity of 64 second-feet. These force the water through a reenforced-concrete pipe into the high-line canal, having an elevation of 50 feet above the settling basin. This high-line canal has a capacity of 60 second-feet at its head, and is designated to supply water for the higher lands in this unit, including 4,0501 acres already within reach of water and 1,375 acres under the proposed extension of the canal. From the settling basin a low-line canal is projected, to have at its head a capacity of 80 second-feet, for the purpose of supplying water to about 6,600 acres on the Buford Flats. From the high-line and low-line canals laterals will distribute water to the farms. This unit, it is stated, is 36 per cent complete. As originally outlined, this unit included an area of about 3,000 acres on the Trenton Flat, which was to be supplied with water by a separate floating pumping outfit to be located near Trenton. Apparently, however, this area is no longer considered part of the unit.

6. The Williston unit in its present condition includes a pumping plant, mounted on a barge in the Missouri River, to force water through steel pipes into a large settling basin located near Williston. On the barge are mounted three electrically driven pumps, having a combined capacity of 90 second-feet for a 30-foot lift. From the settling basin the water flows to the power house through the main, or "A" canal, having an initial capacity of 100 second-feet. One mile from the river is pumping station No. 2, which supplies the "B" canal. It contains two electrically driven pumps with a combined capacity of 35 second-feet under a 28-foot lift. About 1 mile west on the "B" canal pumping station No. 4 is located, in which one electric pump lifts 20 second-feet into the "C" canal, an additional height of 28 feet. At the power house are two sets of steam-driven

pumps. One set has a lift of 56 feet and a capacity of 40 second-feet, discharging into the "E" canal, which extends about 7 miles up the Little Muddy Valley. The other set has a lift of 28 feet and a capacity of 15 second-feet and supplies the "D" canal. From the "A," "B," "C," and "D" canals water is supplied to the lands through laterals, the area now in reach of water being 8,047 acres. As at present outlined the Williston unit includes in addition the irrigation of the west and east bottoms, an aggregate area of 3,100 acres. The irrigation of these bottoms will require the installation of two more small floating pumping outfits, each of which will pump into a settling basin, from which laterals will carry water to the lands. The Williston unit is stated to be 64 per cent complete. This unit originally was intended to include other irrigable lands in the Little Muddy Valley, as well as lands west of Williston. Apparently, however, this work is no longer considered part of the unit.

7. The barges for the floating pump plants and the houses thereon are of wood. Some of the minor structures on the canals and laterals are of wood, others of concrete. Concrete enters largely into the construction of the power house and the pumping plants. The examination of this project by the board showed well-designed and well-constructed power plant, pumping plants, pressure pipes, and settling basins; and the canals and laterals, with the minor structures thereon, seem generally to be good.

8. *Water supply.*—The water supply for this project depends altogether on the capacity of the pumping plant, since there is always an ample supply in the river. Low water in the river, however, affects the capacity of the pumps by increasing the head against which the floating pumping units must operate. The average head is 28 feet. The pumping units were designed to supply 2 acre-feet of water per acre when working continuously for a period of 80 days. It appears, however, that the rated capacity of the pumping units as installed is somewhat short of this, and that to supply the proposed quantity of water the pumps must be operated practically continuously throughout the irrigation season of about 120 days. The supplying of water at this uniform rate makes necessary equal uniformity in its use. The board does not believe that this condition of uniform use, day and night, throughout the season can be fulfilled in practice, and that the margin for contingencies is small. The need for water on the irrigated land is not the same throughout the season, and while the irrigators can come much nearer to uniformity in use of water than they now think possible, it seems to be very probable that at certain times during the irrigation season some of the crops will suffer for lack of water. On the other hand, it should be stated that the lands of this project lie in the semiarid belt, the average annual rainfall being 15 inches, and that 1½ acre-feet of pumped water per acre will probably suffice except for extremely dry seasons. It will be during such very dry seasons, however, when the failure to supply water when actually needed will be most severely felt. Additional pumping capacity can readily be supplied, but only at an additional expense to the lands.

9. *Lands.*—The approved plans, as stated by the supervising engineer, provides for the irrigation of about 12,035 acres in the Buford-Trenton unit and about 11,147 acres in the Williston unit.

Of the total area of 23,182 acres, only about 2,400 acres are public land subject to the reclamation act.

10. Both subdivisons have been partially opened by public notice, the area opened in the Buford-Trenton unit being 4,060 and in the Williston unit being 8,047 acres. The farm unit for private lands is 160 acres and for public land 80 acres. The announced building cost is $38 per acre, with an operation and maintenance charge of $0.70 per acre per year and $0.50 additional for each acre-foot of water supplied to the lands, making a total of $1.70 for operation and maintenance for 2 acre-feet supplied. So far only 2,968 acres in the Buford-Trenton and 6,253 acres in the Williston have made application for water, while the area actually irrigated in 1910 was only 400 acres in the former and 2,000 acres in the latter.

11. The average elevation is 1,900 feet above sea level. This project is in the semiarid belt and in some years will produce good crops without irrigation. This is believed to be partly responsible for the small use made by the farmers of the irrigation water, the year 1909 being a wet year and the pumped water not being needed. The present year, however, has been very dry and the crops on the nonirrigated lands were, in general, failures. During normal years comparison between the crop returns on irrigated and nonirrigated lands shows a substantial increase in yield due to irrigation. The higher lands of the project do not require clearing before being put under cultivation, while on much of the bottom land considerable clearing is necessary. In the Williston unit some of the higher lands are rolling and, therefore, are difficult to prepare for irrigation.

12. The soil is generally of good quality, ranging from sandy loam to a heavy clay loam. The principal crops are the small grains, but alfalfa can be grown with success, as probably, also can sugar beets. Due to the high altitude the growing season is short, but two and often three cuttings of alfalfa can be obtained.

13. Owners of lands under the ditches who have not perfected their water-right applications nor made the required payments will, at the beginning of the irrigation season of 1911, be in arrears for four installments of the building charge and four annual assessments of the fixed charge for operation and maintenance, a total of $18 per acre. Under the terms of the reclamation act, these lands are subject to the cancellation of the water application for private land and of the entry of the land if it is public; but in the event that the land office does not enforce this cancellation these lands can obtain water for the season of 1911 only by the prior payment of $13.50 per acre. The farmers may be at fault for this condition, but it does not seem probable that many of them can make this payment.

14. There is general complaint that the annual charge per acre amounting to $5.50 (including $3.80 for construction costs, $0.70 fixed charge for operation and maintenance, and $1 for 2 acre-feet of water) is more than the land will bear. It appears, however, that, with good methods of farming, the difference in yield per acre on irrigated and nonirrigated land is, in an average year, in value considerably more than $5.50 per acre, while in very dry years like the present, it is a question of a crop or no crop. For this reason the board believes that, while a charge of $5.50 may in many cases be burdensome, the lands generally will bear this charge provided the farmer can start in anew without the handicap of a requirement for

an immediate payment of the accumulated back charges. There is also general complaint from the owners that the annual charges are more than twice what had been promised them; the statement being that they were promised that the annual charge per acre, inclusive of both construction and operation and maintenance, would not be over $2 to $2.50. The par value of the stock of the water users' association is $20 for the Buford-Trenton and $24 for the Williston.

15. The result of the dissatisfaction is that the farmers seem to have no disposition to apply for the water. They are insistent that some modification be made in their contract, either to extend to 20 years the period in which construction charges are to be paid, to arrange for graduated payments, or to waive temporarily the payment of all unpaid back charges and to arrange for collection of the first annual installment of the building charge after the end of the next crop year. The owners of private land within the proposed extensions very generally desire to be released from their agreement with the Government. The board believes that the conditions existing in this project make it desirable that some modification be made in the present requirements which would permit the farmers to obtain one irrigated crop prior to any demand for back charges, or which would provide for a system of graduated payments.

16. *Operation and maintenance.*—The cost of operation and maintenance is claimed by the farmers to be unnecessarily expensive; but since the plant is operated for such a small area, and that area requiring the highest pumping lifts, the operation is necessarily expensive. The shortness of the irrigation season also has a tendency to make cost of operation high, since the plant must be cared for during the nonirrigation season, and since, when the season opens, a large force of temporary employees has to be engaged not only for the power and pump plants but also for the coal mine and for the ditches. Such temporary employees must be paid at higher rates than would permanent employees, and they are not as efficient. The board does not see how the cost of operation and maintenance can be materially reduced, except from the natural result of more lands using the water, and especially from the farmers being educated to use the water in rotation, according to an arranged schedule, instead of all demanding water at one time and thus requiring the maximum output occasionally during the season with intervals between when little water is used.

17. *Costs.*—There has been allotted to this project to date $963,000, of which there was expended to June 30, 1910, $806,465.71 for construction and $98,098.89 for operation and maintenance. There was due the General Electric Co., as balance on a contract, $10,326. Since only $3,978.85 was collected for operation and maintenance, there was a deficit under that head of $94,120.04. The following table shows the probable financial condition of this project on December 31, 1910:

Construction cost to June 30, 1910	$806,465.71
Balance due on contract	10,326.00
Deficit on operation and maintenance to June 30, 1910	94,120.04
Probable deficit on operation and maintenance for remainder of 1910	14,088.25
Total cost to United States to Dec. 31, 1910	925,000.00
Returnable on building charge, 12,316 acres, at $38 per acre	468,000.00
Balance	457,000.00

Therefore, if no extensions are made, the United States will have a loss on the project by the end of 1910 of about $457,000, even if the lien on the lands is considered of value sufficient to cover the amounts charged against them. The above estimated loss will probably be increased for several years to come by deficits for operation and maintenance.

18. *Completion and extension.*—The supervising engineer, under date of August 31, 1910, estimates that the project can be completed practically as outlined for the following costs:

Subdivisions.	Estimate for completion.	Irrigable acres added.
Buford-Trenton subdivision	$160,000	7,975
Williston subdivision	110,000	3,100
Total	270,000	11,075

Thus the completion would reduce the estimated loss on the project to about $300,000. Should conditions justify the opening of this additional area at a higher construction charge than $38 per acre, the loss to the reclamation fund would be further reduced. From this, it appears that it will be advisable to complete the system in case further experience with the irrigable areas already opened shows that the owners of the irrigated lands are securing satisfactory results and that there is a reasonable probability of the additional lands being taken up. In the meantime, however, the board does not deem the completion advisable.

19. Additional areas can be put under irrigation in this region by pumping if conditions warrant. The supply of water is ample and the lands are in easy reach of moderate pump lifts. At present, however, extensions of this project are not advisable.

20. *Summary.*—(1) This project is entirely within the State of North Dakota.

(2) Of the total area of 23,182 acres in the project only about 10 per cent is public land subject to the reclamation act.

(3) The power plant, pumping plant, and the distribution system are well designed and constructed.

(4) While the supply of water in the river is ample, the capacity of the pumping plant is based on a continuous, uniform use of the pumped water, a condition of use difficult to attain in practice, and there is therefore a probability that, with the small margin for contingencies in the pumping capacity, there will be an occasional injurious shortage of water.

(5) Some modification should be made in the terms of the contracts with the farmers on this project which will enable them to obtain one irrigated crop prior to any demand for back charges, or which will provide for a system of graduated payments.

(6) While the annual charge per acre of $5.50 may in many cases be burdensome, the lands generally, with good methods of farming, will bear this charge, provided the farmer can start anew without the handicap of a requirement of immediate payment of accumulated back charges.

(7) The completion of the project as outlined is feasible from an engineering standpoint, but is not advisable until the area now in reach of water is being irrigated with success and is repaying to the reclamation fund the assessment made against it.

(8) In the event of successful results from the present works, the completion of the approved project is desirable, as the addition to the irrigable area will help reduce the loss to the reclamation fund, and will also tend to a reduction of the annual cost per acre of operation and maintenance.

(9) Whether or not the project is completed it appears to be inevitable that there will be a large loss to the reclamation fund.

(10) The estimated final cost of the project is about $1,195,000, of which approximately $911,000 had been expended prior to June 30, 1910.

(11) The following allotment is recommended for the four years, 1911–1914, inclusive:

From the fund	$270,000

Section XX.

UMATILLA PROJECT, OREGON.

1. The board visited the Umatilla project, near Hermiston, Oreg., September 7, and spent the day in examining the feeder canal, Cold Springs Reservoir and Dam, the distributing system, and the lands to be irrigated.

2. A public hearing was held on the evening of September 7, in Hermiston, at which those interested were given an opportunity to make statements and furnish information to the board. In general, they expressed their approval of the work under the project, both as to progress and cost.

3. *Location and description.*—The Umatilla project is located in eastern Oregon in the near vicinity of Hermiston and lies wholly within the limits of the State. Large areas of good land surround this town, which depends for its prosperity upon the neighboring agricultural areas now being irrigated. The project covers the irrigation of about 25,000 acres lying in the angle between the Umatilla and the Columbia Rivers on the east side of the Umatilla, from which river it takes its water supply at a point several miles upstream. The average elevation of the irrigated areas is 470 feet above sea level. The temperature ranges from 28° below zero to 115° F. The Oregon Railroad & Navigation Co. partly traverses this project and also follows its borders on two sides. The Spokane, Portland & Seattle Railway on the other side of the Columbia River affords a second line of transportation.

4. The project includes a diversion dam in the Umatilla River 2 miles above Echo. This dam produces the necessary head for the feeder canal which supplies water to the Cold Springs Reservoir, where 50,000 acre-feet may be stored.

5. The Cold Springs Reservoir lies in a natural depression, about 6 miles east of Hermiston, which is closed by an earth dam across its outlet. Its area is 1,500 acres. The stored water is discharged,

by means of a concrete conduit passing through the dam, into the main distributing canal and thence into the system of laterals.

6. Taking the project as a whole, the engineering structures are apparently satisfactorily designed and executed. The only important engineering structure is the earth dam closing the outlet to the Cold Springs Reservoir. This dam has already withstood almost the maximum head and appears stable, although its height of 98 feet makes it one of the high earth dams of the country. Leakage under the dam, amounting to about 1.3 second-feet, was observed. It is said that increase of head against the dam does not increase the flow materially. This is being watched and is not thought to be serious. It is assumed by the Reclamation Service that this leakage is through seams in the foundation under the dam and at its ends.

7. The main feeder canal, 24½ miles long, has a capacity of 300 second-feet at the reservoir. There are 62 miles of laterals having capacities less than 50 second-feet. The distribution system consists of a main distributing canal, called the "A" line, leading out from the reservoir through a concrete conduit supplied with valves. From this "A" line all the remainder of the system is supplied. Water is carried to the lower laterals through concrete pipes, the intention being to generate electricity at some of the drops and use the power for pumping for the irrigation of a small area lying above the gravity system. One concrete siphon is 9,831 feet long, 46 inches in diameter, and is under 110-foot head.

8. *Water supply.*—The water supply is taken from the Umatilla River and consists exclusively of flood flow. None of the low water discharge is available for the project as all of it has already been appropriated. The drainage area of this river is 1,600 square miles, and the watershed has an elevation of 2,000 feet above sea level. The average rainfall is 20 inches and the average normal run-off is 530,000 acre-feet per annum. Discharge measurements have been kept at Gibbon, Oreg., since 1897 and at Yoakim since 1903. The water rights appear to have never been adjudicated, but application has been made by the United States to the State board of control for a determination of the priority and amount of all claims. This determination is now in progress. The priorities as estimated by the Reclamation Service and the river discharge for 13 years are as follows:

	Area.	Maximum rate of diversion.	Acre-feet required for full supply.
Umatilla project:	*Acres.*	*Sec.-ft.*	
Maxwell Canal	25,000	114	100,000
Feed Canal		350	
Western Land & Irrigation Co.	[1] 10,000	125	25,000
Inland Irrigation Co.	[1] 8,000	100	[2] 20,000 [3] 6,000
Oregon Land & Water Co.	[1] 5,000	60	12,000
Allen Ditch Mill Ditch Pioneer Ditch Courtney Ditch Slusher Ditch Taylor Ditch	2,400	30	6,000
Brownell Ditch	[1] 1,200	15	3,000
Total	51,600	794	172,000

[1] Estimated. [2] Flood. [3] Stored.

The experience of this year (1910) indicates that the return flow to the river will be sufficient to supply the priorities of the Oregon Land & Water Co. and Brownell Ditch Co. This will reduce the total in the tabulation to 719 second-feet and 154,000 acre-feet, respectively. Moreover, since the Maxwell Canal will not be operated prior to March 15 it is not likely that the maximum rate of diversion of the Maxwell Canal and the feed canal will occur at the same time, so it appears that priorities for existing project may be considered as a total of 154,000 acre-feet, and a maximum rate of diversion not exceeding 670 second-feet.

Umatilla River, discharge since 1896 and assumed priorities.

Year.	Total discharge.	Assumed priorities.	Unappropriated.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
1897	572,000	154,000	418,000
1898	408,000	154,000	254,000
1899	770,000	154,000	616,000
1900	(1)	154,000	[2] 200,000
1901	616,000	154,000	462,000
1902	507,000	154,000	353,000
1903	534,000	154,000	380,000
1904	693,000	154,000	539,000
1905	250,000	154,000	96,000
1906	602,000	154,000	448,000
1907	567,000	154,000	413,000
1908	369,000	154,000	215,000
1909	439,000	154,000	285,000

[1] Incomplete. [2] Probably.

It thus appears that the present supply is sufficient to provide water for the proposed project, with considerable surplus.

9. The duty of water is assumed at 2½ acre-feet at the farm, requiring 62,500 acre-feet. If 33 per cent loss from evaporation and seepage be allowed in the laterals and 5 feet evaporation in the reservoir, the total amount required would be about 101,000 acre-feet to supply 2½ acre-feet on the land. The capacity of the reservoir is 50,000 acre-feet and it will be necessary, therefore, that 51,000 acre-feet to be supplied direct from the river. It is estimated by the Reclamation Service from hydrographs that the prolongation of the flood period into the irrigation season will be sufficient to supply this quantity.

10. *Lands.*—The total acreage under this project as above mentioned is 25,000. During the season of 1910, the area for which water was available was 15,319. This leaves 9,454 acres still to be furnished with water under the present proposed extensions. Of the total acreage there were only 4,120 acres of public land subject to entry under the reclamation act. The Northern Pacific Railway owned 1,980 acres, and other land under private ownership, or not subject to the reclamation act, amounted to 18,673 acres. Lands owned by the railroad are now being sold to settlers under contract to apply for water under the terms of the reclamation act. About one-half of the public land is embraced in the proposed continuation of the project which would therefore not receive water if present plans were interrupted.

11. The average rainfall on the project is about 9 inches annually, which is too little for crops without irrigation. The land in this project consists of sandy loam throughout, and is, in a large propor-

tion, volcanic ash. The top surface is underlaid with gravel which assists materially in drainage, so that but little attention has been paid to waste water in the upper portions. In the vicinity of Hermiston there are considerable areas now swamped which will require a more or less extensive drainage system before the project can be utilized to its fullest extent. This will not be difficult and provision therefor has been included in the estimates. The high winds often make necessary the replanting of grain crops when they are not protected by windbreaks. The farm units have been restricted to 10 acres in the close vicinity of Hermiston, to 20 acres in the more remote areas, and to 40 acres near the outer limits of the project. Although the irrigated land in the vicinity of Hermiston is still new, it is now being planted with orchards, both peach and apple, and alfalfa is also being seeded. Some vegetables are being grown and berry bushes have been set out. The hopes of the settlers are that this area will equal some of the Wenatchee and Yakima lands in fruit products, such as apples, peaches, and grapes, and already land has been sold for $200 per acre, exclusive of construction charges. Should this hope of productiveness be realized, it seems plain that a high construction cost can be supported without hardship. The charge already fixed by the Reclamation Service for this land is $60 per acre and applies to 18,200 acres. The cost of operation and maintenance, as fixed by the Reclamation Service, is $1.30 per acre.

12. *Cost of the project.*—The amount expended on this project up to June 30, 1910, has been $1,211,827.71, which includes maintenance and operation charges amounting to $61,624.91. The project is about 70 per cent completed. The cost of completion is estimated by the Reclamation Service at $330,000, in addition to present allotments, with which it is expected to irrigate new areas lying between the present completed portions of the system and the Columbia River, and, also, a new strip of land lying between the feeder canal and the permanent lateral of the distributing system known as the "A" line. It is also expected to drain some of the swamped areas.

13. *Returns to the reclamation fund.*—The amount set by the Reclamation Service as a building charge is $60 per acre. This was originally believed to be ample, but it was found later that increased charges would be necessary. The $60 charge applies to 18,200 acres. To cover the cost it is now expected to charge $75 per acre for one unit of 3,130 acres and $100 per acre for one unit of 3,300 acres. At these rates, if all the land is taken up, the return will be $1,656,750. As the total estimated cost is $1,650,000, there will be no loss unless the estimates for completion are exceeded. It is doubtful whether the higher-priced lands will be rapidly taken up. There is still a deficit on account of operation and maintenance of about $41,000, which it is believed by the Reclamation Service will be returned to the fund in 10 years by retaining the present charge of $1.30 per acre, which will, it is expected, exceed the actual cost when the entire area is irrigated. In this connection it is noticed that the par value of stock in the water users' association is $60. If the higher payments are not fully secured by a lien on the land under the present agreement with this association and its members, new agreements should be made covering the higher-priced land.

14. *West extension.*—The people of Hermiston and vicinity are very desirous that the Government extend this project to the west side of

the Umatilla River, where the reclamation of from 40,000 to 60,000 acres of land by a gravity system is proposed. This extension was the main subject discussed at the public hearing. This development, while being properly an extension of the Umatilla project, inasmuch as it would receive its water from the same source and lie contiguous to the areas at present being irrigated, yet is in the nature of new work as its development bears in no way upon the completion of the present unit of the project. The extension would require the construction of a reservoir of a capacity of about 135,000 acre-feet by building a dam in the Umatilla River near the mouth of Butter Creek. The water surface would be raised about 70 feet, and the supply would then be distributed over the land by a gravity system. This gravity plan could be supplemented to cover about 30,000 acres more by electric pumping, should this further extension be deemed desirable. Reservations on the Des Chutes River for a dam site with which to develop power have been made, the power to be used in pumping water from the gravity canals or from the Columbia River to the areas not irrigable by any gravity system. If the water supply is sufficient, the total area of the proposed extension can be expanded to about 100,000 acres, including the pumping project.

15. Experience on the Umatilla project and on private projects at Irrigon and Kennewick indicates that the soil is abundantly able to produce fruits and alfalfa as well as vegetables and berries. The climate is suitable thereto, and although the areas are swept by strong winds throughout the spring of each year the soil can be protected by cultivating windbreaks. Of the area under the proposed gravity system there are but 17,000 acres of public land. The remaining land belongs either to the Northern Pacific Railroad or is now in private ownership through homestead and desert-land entries, or through purchase from the railroad. Hydrographs for 12 consecutive years indicate that there will be a surplus of over 200,000 acre-feet, making allowances for private rights and the requirements for the main Umatilla project.

16. Allowing 5 feet evaporation on the average area of the proposed reservoir—3,200 acres—and a loss of 5,000 acre-feet for a 6 per cent loss in the distribution, a total loss of 21,000 acre-feet of storage water is to be provided for. The use of concrete-lined distributaries is proposed by the Reclamation Service, which it is expected will reduce the losses from seepage to the low amount stated. By using flood water direct it is calculated from the records by the reclamation engineers that a surplus of 22 acre-inches only will need to be stored, which gives a total of 112,000 acre-feet necessary in a season, allowing 23,000 acre-feet of stored water to be carried over if the reservoir were filled. It thus appears from these assumptions that the water supply will be sufficient for 50,000 acres if the proposed reservoir be built.

17. The cost of this extension, exclusive of the pumping system, but including the dam across the Umatilla River with its accessories, estimated at about $1,000,000, amounts in all to nearly $4,000,000. This is approximately $80 per acre for an area of 50,000 acres.

18. *Summary.*—(1) The project is feasible and practicable from an engineering and economic standpoint.

(2) The project lies wholly within the limits of the State of Oregon.

(3) The total area of land to be irrigated is 25,000 acres, of which about 16 per cent is public land subject to the reclamation act.

(4) The water supply is sufficient for the area of the present project.

(5) The proposed west extension being entirely distinct should be postponed for the present on account of the large amount of money needed for the completion of other projects to which the United States is committed by the large expenditures already made.

(6) The total estimated cost of the work is $1,650,000, of which about $1,212,000 has already been expended.

(7) The land can bear the cost of construction estimated at $60, $70, and $100 per acre, although that subject to the higher charges may not be rapidly taken up.

(8) The project as now adopted is worthy of completion in view of the advanced condition of the work.

(9) The following allotment is recommended for the four years, 1911–1914, inclusive:

From the loan	$325,000

Section XXI.

KLAMATH PROJECT, OREGON AND CALIFORNIA.

1. The board visited this project on September 30 and October 1 and 2, 1910. A public hearing was held at Bonanza on September 30 and at Klamath Falls on the evening of October 1.

2. *Location.*—The lands of this project are located in Klamath County, Oreg., and in Siskiyou and Modoc Counties, Cal. Transportation facilities at the present time consist of a branch of the Southern Pacific Railway, called the California & Northeastern Railway. Upon completion, this branch will form a through line between Portland and San Francisco. Surveys for two other lines are reported as reaching the vicinity of Klamath Falls, one of which, if constructed, will give an outlet to the east.

3. *Historical.*—The original plans included what was known as the "upper" and "lower" projects. The "upper" project, according to preliminary surveys, comprised an area of 48,350 acres, and included Langells, Yonna, and Upper Poe Valleys. The "lower" project, from the preliminary surveys, comprised an area of 188,045 acres situated in Klamath and Lower Poe Valleys. This area included the marsh lands to be reclaimed around Lower Klamath Lake and those to be uncovered by the lowering of Tule Lake.

4. Before beginning work, the Reclamation Service purchased certain private rights and canals as follows:

(1) The property and rights of the Klamath Canal Co.

(2) The property and rights of the Little Klamath Water Ditch Co. (Adams Canal).

(3) The property and rights of the Klamath Falls Irrigating Co. (Ankeny Canal).

(4) The Keno Canal, belonging to Moore Bros.

5. The Klamath Canal Co. and the Ankeny Canal controlled the situation on the east side of the outlet of the Upper Lake, the main

source of the water supply. They owned certain essential rights of way and irrigated a small amount of land. The Adams Canal was a private canal taking water from White and Lower Klamath lakes and this interest prevented the lowering of the latter lake, a necessary preliminary to the reclamation of the Klamath marsh lands. This canal occupied rights of way and irrigated lands which it was desired to have in the project. The Keno Canal controlled the outlet on the west side of the Upper Lake and held certain riparian rights which it was thought desirable to obtain. As a part of the purchase price of this canal, the Reclamation Service agreed to deliver in perpetuity to the Moore Bros. at their power plant 205 second-feet for power purposes. A part of the original plan was the construction of a reservoir at Clear Lake, and for this purpose the Carr ranch was bought. This purchase also extinguished the riparian rights of the owners around Tule Lake, which was to be lowered.

6. The main canal for the project was located on the east side of the outlet of Upper Klamath Lake, and a capacity of 1,500 second-feet was required. Before any radical changes were made in the project this canal was constructed to its proposed length and dimensions. For irrigation and power purposes and to deliver to the Moore Bros. the 205 second-feet due them by contract, the Keno Canal was constructed to carry 650 second-feet. This canal terminates at the Moore Bros. power plant. Owing to changes in plans this canal has not been extended.

7. The project at the outset was further complicated by the fact that both Upper and Lower Klamath Lakes are navigable waters, together with a portion of Klamath River between Klamath Falls and Keno. Navigation can not be carried on between the lakes, but small craft can pass from Lower Klamath Lake to Klamath River. Upper Klamath Lake lies wholly in the State of Oregon, while Lower Klamath Lake lies partly in California and partly in Oregon. As the original plans of the Reclamation Service contemplated changes in the channel of Klamath River, a possible lowering of Upper Klamath Lake, and the lowering of the level of Lower Klamath Lake, acts of the legislatures of the States of California and Oregon were obtained, authorizing the United States to lower or change the levels of the lakes in question, and ceding to the United States any lands not previously disposed of which might be uncovered by the lowering. The Congress also passed an act (February 9, 1905) authorizing the Secretary of the Interior to make such changes in the levels of the lakes in question as might be deemed necessary in carrying out any irrigation project under the reclamation act. Under these acts the Secretary of the Interior entered into a contract with the California & Northeastern Railway Company by which the latter was to carry its railway across the upper portion of Lower Klamath Lake in a manner prescribed by the Reclamation Service. The United States is obligated under this contract to assume all responsibility for any interruption to navigation. The act of Congress, while authorizing the changing of the lake levels, does not expressly authorize the closing of the lakes to navigation. The embankments constructed by the railway under this contract interfered with navigation between the lake and Klamath River. The board is informed that action is now pending for damages on

account of the interference with navigation, in which the United States is made defendant on account of the obligation assumed in the contract with the railway.

8. Owing to the construction charges having proved higher than was expected by the citizens, much dissatisfaction was expressed and large areas of land subscribed to the project as above outlined were released. Other large areas of private land which it was expected would subscribe did not do so. The project has, therefore, been materially changed in its outlines.

9. *Description of present project.*—The project as now proposed has three approved subdivisions and two which have not yet received executive approval. All are described as follows:

(*a*) *Lower project uplands.*—This portion of the project, 37,000 acres in area, includes a strip of valley land extending northwesterly and southeasterly between Klamath and Tule Lakes, together with Poe Valley. This valley and the easterly portion of Klamath Valley are traversed by Lost River, a stream having its headwaters in Clear Lake and discharging into Tule Lake. This river has so little fall and is generally so far below the surface of the surrounding land as not to be available, except to a limited extent, for irrigating these two valleys. Water for this subdivision comes from Upper Klamath Lake through the main canal and distributing system, although 1,800 acres will be irrigated by water from Lost River diverted at the proposed Wilson's bridge dam.

(*b*) *Tule Lake subdivision.*—This includes 35,000 acres, all to be uncovered by lowering Tule Lake. This lake covers 96,000 acres. It is of fresh water and is fed by Lost River. It has no known outlet, but a small amount of water escapes at the southerly end into the crevices of the lava beds. By artificially enlarging some of the crevices the discharge was temporarily increased from 10 second-feet to 32 second-feet, but as the lake subsided the outflow decreased; and it seems probable, therefore, that no reliance can be placed on this method for lowering the lake. In 1888 the Klamath River broke through its banks at a point three miles south of Klamath Falls, diverting a considerable amount of water through Lost River Slough and Lost River to Tule Lake. This caused a rising of the lake until the settlers closed the break by a levee. After a comprehensive study of the situation it is proposed by the Reclamation Service to reclaim from thirty-five to forty thousand acres of land around the northern end of the lake by the following plan: First, the utilization of the reservoir at Clear Lake to regulate the discharge of Lost River. This also provides water which can be used for the irrigation of lands elsewhere. Second, construction of a diverting dam on Lost River at Wilson's bridge and a diversion channel of 250 second-feet capacity connecting Lost River with Klamath River. This capacity of 250 second-feet provides for a constant discharge from Lost River of 200 second-feet, and for 50 second-feet estimated return flow from lands along Lost River irrigated from Upper Klamath Lake. Third, a dike to be built across the northerly end of the bed of Tule Lake to prevent flooding of the lands after being reclaimed. Fourth, pumps at the dike to pump drainage water from behind the dike to irrigate a narrow strip of land along the easterly side of the lake. Fifth, a diversion dam near the present mouth of Lost River, together with a distributing system of canals and laterals, as well as

drains, in the reclaimed area. By these means it is proposed to keep all Lost River water out of Tule Lake except such flood flow as can not be controlled by the reservoirs. The main canal from the Upper Klamath Lake, now used only to water the first subdivision, was constructed with a capacity sufficient to irrigate these Tule Lake lands. Attention is called to the fact that the successful use of these tule lands after being reclaimed depends largely on the prevention of subirrigation from seepage from the higher irrigated lands around them and upon the success of the plan to control Lost River floods by means of Clear Lake Reservoir, the diversion channel, and the dike.

(*c*) *Marsh lands.*—It was proposed originally to irrigate the reclaimed marsh lands by means of the main canal which was given sufficient capacity for the purpose as far as constructed. The drainage was to be effected mainly by the construction of the Keno Cut and tunnel, involving excavation in the Klamath River to lower its level, the improved channel to lead to a tunnel cutting through the bend below. Power was to be developed at the lower end of the tunnel. As these plans proved, on more detailed investigations to be too costly, they were abandoned. The construction of the embankment and trestle of the California & Northeastern Railway across the marshes will, when the embankment is made continuous, divide the marshes and necessitate separate treatment of the two portions. Several plans for the reclamation of these marsh lands have been considered by the Reclamation Service. Inasmuch, however, as the efforts of the Agricultural Department at its experiment farm near Ady to cultivate these marsh lands after being drained have been unsuccessful, the board does not consider it advisable to expend further money on the reclamation of these lands until the agricultural possibilities are better known. In connection with the marsh land subproject, request was made by parties interested that the Government require the railway to close its embankment across the marshes and install the gates for the control of the inflow and outflow of Lower Klamath Lake in the concrete structures provided for the purpose; that the connection of the Adams and Van Bremmer canals with White and Lower Klamath lakes be severed and the lands under these canals receive water from the main canal as contemplated in the final completion of the project; and that the Government make a small amount of excavation, estimated to cost $50,000, in the upper part of Ankeny Falls, Klamath River. The parties then desire to be released from their subscriptions and be allowed to experiment with reclaiming their marsh lands which lie south and east of the railway embankment. In view of the conclusions of the board with regard to this subdivision, any work in connection with these lands involving additional expense to the United States is considered inadvisable. It is recommended that private lands in this subproject be released from their obligations.

(*d*) *Upper subproject.*—It is proposed to irrigate certain lands on the north side of Lost River, together with a small area to the south of that river, and lands in the Yonna Valley, by water stored in Horsefly Reservoir, located on the headwaters of Miller Creek, a tributary of Lost River. The lands at present included in it were originally subscribed to the main project in the belief that the construction charge would be about $20 an acre. As it was subsequently found that this cost would be much greater, the owners were released from their

agreement. Under the present plan and the estimated charge about 75 per cent of the landowners have again subscribed. This subproject has not received executive approval. The main features comprise the reservoir dam at the headwaters of Miller Creek, a diverting dam in the creek in the vicinity of the lands to be irrigated, and the necessary canals and laterals.

(*e*) *Modoc subproject.*—As Clear Lake Reservoir could not be used to irrigate lands in the lower Langell Valley, as originally contemplated, it became desirable to develop some other use for these waters, and a reconnoissance showed that this water might be diverted to lands in Modoc County, Cal., and also to the narrow strip of lands in Oregon on the east and north of Tule Lake, above the irrigating system under the first subdivision. It would appear from investigations now in progress that about 18,000 acres can be irrigated at a cost of about $64 per acre. If this plan is adopted the land should bear its proportion of the cost of Clear Lake Reservoir.

10. The main engineering features of the project comprise the storage dam at Clear Lake, the main canal leading from Upper Klamath Lake on the east side, the Keno Canal leading from Upper Klamath Lake on the west side, the diversion dam in Lost River, the diversion channel from Lost River to Klamath River, the dike in Tule Lake, the laterals and subsidiary distributing system, and a power plant and distribution of electrical power for sale and for pumping water for irrigation and drainage in Tule Lake subdivision. These features present nothing unusual or difficult in design or execution. Those that are constructed appear to have been well designed. The main canal will carry only 500 second-feet, but was constructed, as stated above, with a capacity of 1,500 second-feet. The Keno Canal will not now be used to supply water for irrigation, though originally designed to do so.

11. *Water supply.*—The water supply for the project as herein considered is to be obtained from three sources—Upper Klamath Lake, Clear Lake Reservoir, and Horsefly Reservoir on Miller Creek. Upper Klamath Lake has a drainage basin of 3,100 square miles, with an average annual rainfall of about 20 inches. It has an area of 66,000 acres. A storage of 200,000 acre-feet can be provided at small cost. This lake will supply all the water for the lower project uplands and for Tule Lake reclaimed lands except 100 second-feet, the total required for both subprojects being 720 second-feet. Lower Klamath Marshes, if reclaimed, will derive the necessary water from Link River, diverted at a point below the power plants on the Keno Canal. The upper subproject will receive its waters from Horsefly Reservoir and the Modoc subproject from Clear Lake Reservoir. There are certain undefined water rights claimed in Upper Langell Valley that will have to be satisfied, to the extent allowed, from Clear Lake Reservoir. These rights are now being adjudicated, but are not believed to be large enough, even if found valid, to affect the use of the reservoir for the Modoc subproject. The adjudication, however, should be completed before proceeding with this subproject. An analysis of the water supply for the whole project is included in the appendix to this section, and it is there shown that there will be sufficient supply for each of the subprojects, attention being called to the water rights claimed in the Langell Valley affecting the Modoc subproject.

12. Intimately connected with this question of water supply is the reclamation of the Tule Lake lands. This is to be accomplished mainly by evaporation, the supply of water being cut off except in times of floods, by the storage reservoirs, the diversion channel connecting Lost and Klamath Rivers, and the use for irrigation of 100 second-feet of Lost River flow which enters Lost River below the Clear Lake Reservoir. The rate at which Tule Lake would recede under the measures proposed is also discussed in the water-supply appendix. From this study it would appear that about nine years would be required to reduce Tule Lake so that 35,000 acres of land could be reclaimed. The studies of the Reclamation Service relative to this subject have been comprehensive, but there are many elements entering the problem, such as run-off from the surrounding drainage basin, future rainfall, seepage from lands now being placed under irrigation, that are more or less indeterminate, and time alone can decide whether the assumptions made are warranted. That 35,000 acres of these lands can eventually be reclaimed in the manner proposed seems probable.

13. *Lands.*—The average elevation of the irrigable area is 4,100 feet above sea level, and the average annual rainfall is 15 inches. Dry farming is possible, and in years of more than average rainfall is profitable. The irrigable land under the five subdivisions is shown in tabular form as follows:

Subdivision.	Private.	State.	Public.	Total.
Lower project uplands	36,300	.....	[1] 700	37,000
Tule Lake lands	3,100	.....	[1] 31,900	35,000
Lower Klamath Marshes	27,000	.....	[2] 27,000	54,000
Upper subproject	14,000	500	1,500	16,000
Modoc subproject	8,000	1,000	9,000	18,000
Total	88,400	1,500	70,100	160,000

[1] These lands were originally practically all State lands, but were deeded to the United States by States owning same for homesteads, under condition that the lands should revert to the State if not reclaimed.
[2] Fourteen thousand public and thirteen thousand State lands ceded under conditions in note 1.

Of the 160,000 acres, 70,100 are public lands subject to the reclamation act, 88,400 are private, and 1,500 acres State. Omitting the marsh lands, the total is 106,000 acres, of which 43,100 are public, 61,400 private, and 1,500 acres are State.

14. The soil in the first subdivision is generally decomposed basalt of good fertility. In the lower part near Tule Lake there is much fine sand, making it difficult to cultivate. The soil is fairly deep, but is underlaid with diatomaceous ash, more or less impervious, rendering drainage essential. The duty of water is 1.8 acre-feet per annum at the farm. Under this first subdivision the first unit of 27,776 acres of subscribed land and 1,771 acres of land to which water free of construction charges was to be furnished was opened November 18 and December 7, 1908. At the present time 24,860 have made application for water. Reports for 1910 are not available, but in 1909 18,471 acres were irrigated, the total value of the crops being reported as $327,220. There are two portions of this first unit which require drainage and this is to be provided by the Reclamation Service. An item of $10,000 is included in the estimate for this purpose.

15. The land in the Tule Lake subdivision is largely public, but is wholly covered at present by the lake. The soil immediately around the lake seems fertile, and much land now covered, due to the rising of the lake in recent years, was formerly exposed and was then equally good. The indications are that the lands reclaimed will prove fertile.

16. The marsh lands around Lower Klamath Lake are about half public and half private. So far experiments with this land have not given favorable results. It appears to be very difficult to work, is very much like peat, and several years are necessary before the soil can be reduced to a cultivable state capable of growing any crop.

17. The upper subproject lands appear to be of good quality and are easily drained. The owners are desirous of having water brought to their lands.

18. The Modoc subproject lands likewise are of good quality and easily drained. The settlers are very desirous of having this subdivision irrigated, as the lands included are high and they think well suited to fruits.

19. The last two subdivisions are not as yet part of the approved project, and whether the waters of Clear Lake will be applied to the Modoc lands or to the lands north of Langell has not yet been decided. The Langell lands have not been included in any proposed subproject, as a large part of them are held in large tracts whose owners decline to subscribe.

20. *Costs.*—Expenditures to June 30, 1910, have been $1,905,715.37. The estimated cost of completion of the five subdivisions is shown in the following table:

(*a*) Lower project uplands:	
Expenditures made and charged to this account	$857,288
Estimated to complete	199,980
Total	1,057,268
Acreage, 37,000; approximate building cost, $28.57; announced charge, $30.	
(*b*) Tule Lake reclamation:	
Expenditures made and charged to this account	621,506
To complete	854,000
Total	1,475,506
Acreage, 35,000; approximate construction charge, $42.16.	
(*c*) Reclamation marsh lands:	
Expenditures made and charged to this account	377,420
To complete	1,432,242
Total	1,809,662
Acreage, 54,000; approximate construction charge, $33.51.	
(*d*) Upper subproject:	
Expenditures made and charged to this account	21,379
To complete	775,000
Total	796,379
Acreage, 16,000; approximate construction charge, $49.77.	
(*e*) Modoc subproject:	
Expenditures made and charged to this account	12,490
To complete	1,132,920
Total	1,145,410
Acreage, 18,000; approximate construction charge, $63.33.	
Total to complete the five subprojects	4,394,142.00
Total estimated cost	6,279,857.37

In this table the previous expenditures have been adjusted by the Reclamation Service among the five subprojects in as nearly equitable proportions as now practicable.

21. It is believed that the lands in all the subprojects, except the marsh lands, can bear the probable construction charges.

22. The par value of the stock of the water users' association has recently been increased from $20 to $30. This new value will cover the construction charges of the first subdivision. In the other four, the estimated construction charges range from $33.51 to $63.33. It is believed that these subdivisions should be dealt with independently through new associations or trustees, the lands to be bound to the full construction charges before large expenditures are made.

23. *Comments.*—Due apparently to insufficient information as to construction costs at the time this project was undertaken, radical changes in the plans and scope of the project have been necessary. The main canal and the Keno Canal were both constructed before these changes were made and are much larger than needed in the present proposed development, though the latter can be made of use in the development of power. The inclusion of the Klamath marsh lands within the project and the expenditure thereon of about $300,000 without knowing their agricultural possibilities was unwise.

24. *Summary.*—(1) This project is interstate in character, the irrigable area lying partly in Oregon and partly in California.

(2) Of the total lands, 106,000 acres, exclusive of the marsh lands, 43,100 acres, or 40.6 per cent, are public lands subject to the reclamation act, of which 700 acres are in the lower project uplands, 31,900 acres are Tule Lake lands, 1,500 are in upper subproject, and 9,000 in the Modoc subproject.

(3) Water supply is sufficient.

(4) The total estimated expenditures, exclusive of marsh lands, is $4,470,195.37, of which about $1,500,000 was expended to June 30, 1910, as follows:

Lower project uplands	$857,288
Tule Lake	621,506
Upper subproject	21,379
Modoc subproject	12,400

(5) The lands, exclusive of the marsh lands, will bear the construction charges estimated as follows:

	Per acre.
Lower project uplands (announced)	$30.00
Tule Lake lands	42.16
Upper subproject	49.77
Modoc subproject	63.33

(6) (*a*) The lower project uplands or first subdivision is feasible from an engineering and an economic standpoint and worthy of completion.

(*b*) The construction of the Tule Lake subdivision should be taken up tentatively to allow further study of the reclaimed lands and the efficiency of the proposed means of controlling the lake area.

(*c*) The upper subproject is an extension not yet approved. It is feasible from an economic and an engineering standpoint, but owing to the necessity of completing more important work elsewhere and to the small amount of public land involved, it is not advisable to prosecute it at the present time beyond such preliminary work as will enable definite plans to be made.

(*d*) The Modoc subproject is feasible from an economic and an engineering standpoint, but it has not yet received Executive approval. Owing to the large amount of public land in this subproject, and to the fact that the water supply therefor is already provided in Clear Lake Reservoir, it is regarded as worthy of completion as funds are available, subject to the adjudication of water rights in Upper Langell Valley.

(*e*) The development of the marsh land subdivision around Lower Klamath Lake should be postponed until it has been shown that the lands can be made productive when cultivated.

(7) Keno Canal power should be developed as needed by the project; the excess power should be developed in cooperation with the water users' association in such manner as to insure return of cost to the United States.

(8) The par value of the stock of the water users' association is sufficient to cover the construction charge on the first subdivision only. For the remaining subdivisions new arrangements should be made by which the land will be bound for the full building charge.

(9) The following allotment is recommended for the four years, 1911–1914, inclusive:

From the loan $600,000

Section XXII.

BELLE FOURCHE PROJECT, SOUTH DAKOTA.

1. The board visited the Belle Fourche project on August 8 and 9, inspecting the headworks at the town of Belle Fourche, the dam, the reservoir site, and part of the distribution system on the 8th, and the lands under irrigation and those which it is proposed to irrigate on the 9th. An informal public hearing was held at the railroad station at Belle Fouche on August 9, at which time those interested were given an opportunity to express their views with regard to the work on the project.

2. The Chicago & Northwestern passes through the town of Belle Fourche, and the Belle Fourche Valley & Northwestern, a branch line, runs diagonally through the irrigated land. Good facilities for shipping products are thus provided.

3. *Location and description.*—The Belle Fourche project is located on both sides of the Belle Fourche River in the northwestern part of South Dakota, northeast of the Black Hills. The land and the water supply are all within the limits of that State. The general elevation of the land in the project is from 2,600 to 3,000 feet above sea level and the temperature ranges from 25° below zero to 100° F. The project consists essentially of a diversion dam in the Belle Fourche River about 2 miles below the town of Belle Fourche, S. Dak., which diverts the greater part of the flow of this stream into an inlet canal. This dam, at its northern end, is provided with headworks admitting water into the canal which supplies a large storage reservoir formed in the bed of a small stream, known as Owl Creek. This creek is closed by a high earth dam in which are placed

two concrete culverts with regulating gates, from each of which leads a distribution canal carrying water to the farms through minor laterals. The inlet canal for supplying the reservoir from the Belle Fourche River is a large one, having a capacity of 1,635 cubic feet per second. It has a length of 6½ miles. The reservoir has an area of 8,010 acres and a total storage capacity of 204,000 acre-feet. The north distribution canal has a capacity of 650 second-feet and will ultimately irrigate 60,000 acres; and the south distribution canal has a capacity of 300 second-feet and will irrigate 40,000 acres.

4. *Water supply.*—Owing to the fact that there are no prior filings below the diversion dam all of the water supply of the Belle Fourche River which reaches this dam is available for direct irrigation or storage. Above the dam there is considerable irrigation, particularly on Red Water and Spear Fish Creeks, tributaries of the Belle Fourche River, but no extension of this work can be made under State law if it interferes with the Government project. The present supply, therefore, seems to be amply protected.

5. A complete record of the flow of the Belle Fourche River at the diversion dam has been kept since June, 1903 (except during 1907, when the gaging station was destroyed), and an analysis of the results to and including 1909 shows that the total quantity and its distribution throughout the year were such as to have permitted the diversion through the present inlet canal of the amounts shown by the following table. These totals cover only nine months in each year, excluding December, January, and February, during which ice would probably obstruct the flow.

Run-off of the Belle Fourche River and Owl Creek.

Years.	Run-off of the Belle Fourche River.	Run-off of Owl Creek.	Total.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
1903	116,280	35,000	[1] 151,280
1904	261,470	38,000	299,470
1905	290,960	37,200	328,160
1906	252,310	34,700	287,010
1907	[2] 240,000	39,000	279,000
1908	218,710	18,400	237,110
1909	217,800	31,000	248,800
Mean of 1903 to 1909	246,875	33,050	279,925

[1] Part year only. [2] Estimated.

NOTE.—No record of run-off of Crow Creek. (Drainage area, 125 square miles.)

5. The run-off of the Belle Fourche River for the first part of 1910 was notably less than for the corresponding part of any previous year of recorded flow, the amount between March 1 and July 31 being only 40 per cent of that for the corresponding period of 1909.

6. The duty of water on this project is estimated at 2 acre-feet per acre per annum, measured at the farm, and the area included in the project is 100,000 acres.

7. Evaporation losses on the reservoir may be roughly estimated at 18,000 acre-feet and seepage and evaporation losses in the canals at 25 per cent, which would leave approximately 200,000 acre-feet for delivery to the farms. Some of the above losses will be offset by the

inflow from Crow and Indian Creeks, so it is apparent that in normal years the water supply will be sufficient for the needs of the project. The partial measurements for 1910 indicate that there would have been a shortage of water had the entire area under the project been in cultivation, but an occasional shortage of this kind does not affect the feasibility of the project, as the cost of providing for such abnormal conditions would probably be greater than the resulting benefits.

8. *Land.*—The irrigable area is about 100,000 acres, of which 50,000 acres are private land, 20,000 withdrawn from entry, 21,600 acres entered subject to the reclamation act, 2,946 open to entry, and 5,515 acres State school land which will be sold to private owners. Practically all the public land thus far opened has been entered for settlement, there remaining but about 40 farms not taken up. The farm unit on public land is 80 acres, except within 2 miles of town sites, where it is reduced to 40 acres. On private land it is 160 acres.

There were 47,568 acres of land ready to be irrigated in 1910, leaving the remainder to be brought under irrigation by extensions of the lateral systems. There were 23,500 acres actually supplied with water. The soil on the north side of the Belle Fourche River is usually clay loam of the gumbo type and difficult to work, several years being necessary to subdue it, but it is productive when cultivated. The soil on the south side is lighter, and the lands on this side are more sought after. The rainfall is about 15 inches, and the region is therefore classed as semi-arid. Dry farming is practiced to some extent, but the crops are only one-fourth to one-half the crops on irrigated land, and are failures in some years. The crops are grain, corn, alfalfa, potatoes, and possibly fruit. Irrigated land sells at prices varying from $40 to $50 for raw land and from $75 to $100 when brought thoroughly under cultivation. The character of the land does not warrant high construction charges for irrigation, but it is believed that the charge of $30 already fixed for the first unit and the charge of $35 suggested by the Reclamation Service for the remainder can be easily borne, together with charges for operation and maintenance of about $0.50 per acre per year.

9. *Distribution system.*—The distribution system is in two units, one being served by the north side canal and the other by the south side canal. The north side canal has a capacity of 1,600 second-feet for a length of about a half mile, and from there on a capacity of 650 second-feet. It has been completed and is in use for a distance of 9 miles to Indian Creek. It is now being extended for an additional length of 36 miles. The south side canal is smaller, having a capacity of 350 second-feet, and has been completed to the Nine Mile Creek, a distance of 45 miles, nearly its full projected length. It crosses to the south side of Belle Fourche River in a concrete siphon 3,565 feet long and 5 feet in diameter. The distribution system now completed covers less than one-half of the whole project. The remaining areas are to be covered by the extensions now being made, and lie mainly under the north side canal. Some drainage will likely be necessary to prevent swamping.

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10. *Cost of the project.*—The total cost of the project up to June 30, 1910, has been $2,394,157.01. The estimated cost of completion is $755,863, as follows:

Belle Fourche Dam	$95,839
North canal and laterals	630,024
Nine-mile lateral	30,000
	755,863

11. *Returns to the reclamation fund.*—The price of $30 per acre to cover construction charges was set in 1907 considerably in advance of the completion of the later units. This figure is too small, but 11,293 acres were opened to settlement in June, 1907, under this charge, and about 35,000 acres more were reached by the ditches in 1910, and were officially opened in February, 1910, for the same building charge. For the remainder of the land it will be necessary to set a new and somewhat higher construction charge if the total cost is to be returned to the reclamation fund. The settlers who were on the ground when the project was started, many of whom were owners of patented land, applied for water under the reclamation act under the agreement that charges over the entire project were to be uniform. The price of $30 was set later, so that a higher charge can not apply to areas covered by the early applications without modification of the contract. It is expected by the Reclamation Service to charge $30 per acre for 70,000 acres and $35 per acre for 30,000 acres, the total of which amounts to $3,150,000. If all the lands under the project were to be finally disposed of at these charges and the present estimates for completion not exceeded, the expected returns would just cover the cost. The cost of operation and maintenance has exceeded the returns at the charge set of $0.40 per acre per annum, and a deficit of about $4,000 exists in consequence. This charge has now been raised to $0.50, which it is expected will refund the deficit in several years. Should drainage be found necessary, it is believed that this should be paid for by assessments against the land under operation and maintenance charges.

12. *Comments.*—In general the work seems well adapted to the purpose for which designed. The earth reservoir dam has been constructed with slopes somewhat steeper than is customary in dams of this type and height. Some flow is noticeable at the lower toe of the dam, although but little water was in the reservoir at the time when the dam was inspected. The board believes that the dimensions of the dam should be made the subject of further study, and that the leakage be kept under constant observation. A fuller description and discussion is appended. In general, the project appears to be feasible and practicable in an engineering and economical sense.

13. *Summary.*—(1) This project with its water supply lies wholly within the limits of the State of South Dakota.

(2) The area of the irrigable land in the project is 100,000 acres, of which the amount of public land subject to the reclamation act is about 45 per cent.

(3) The total estimated cost is $3,150,000, of which about $2,400,000 has been expended.

(4) The project is feasible from an engineering and economic standpoint and is worthy of being completed.

(5) The water supply is sufficient for the area now proposed for irrigation.

(6) The land is productive and can readily refund the construction charge of from $30 to $35.

(7) The advanced condition of the work, the promptness with which the land has been taken up by settlers, the relatively large areas of fairly productive land, and the comparatively low cost of irrigation render it desirable to continue the work at an economical rate of progress until completed.

(8) The following allotment is recommended for the four years, 1911–1914, inclusive: From the fund, $480,000.

Section XXIII.

STRAWBERRY VALLEY PROJECT, UTAH.

1. The board visited this project September 15, 16, and 17 and met the directors of the Strawberry Valley Water Users' Association, at Provo, on September 16.

2. *Location.*—The project lies wholly within the State of Utah, the irrigable area being on the southeast shore of Utah Lake, about 60 miles south of Salt Lake City and surrounding the towns of Payson, Spanish Fork, and Salem.

3. Excellent transportation facilities are afforded by the San Pedro Los Angeles & Salt Lake Railroad and by the Denver & Rio Grande Railroad, both of which traverse the project.

4. *Description.*—The project contemplates the irrigation of 60,000 acres of mesa and bottom land, all in private ownership, with certain possible extensions, which will be referred to hereafter. Much of the area under the project proper is now under cultivation, and has been for many years. About 30,000 acres are now being partially irrigated from Spanish Fork River and certain small creeks, and dry farming is practiced on part of the remainder.

5. Of the land irrigated, it is estimated that in normal years about 8,000 acres receive a full supply, and that occasionally there is a fair supply for approximately 20,000 acres during the entire season.

6. The object of the work undertaken by the Reclamation Service is to supplement the flow of the Spanish Fork River by bringing an additional supply through the rim of the Great Salt Lake Basin from the Colorado River drainage. This involves the construction of a reservoir in the valley of the Strawberry River, a tributary of the Duchesne River, and the diversion of the water thus stored by a tunnel nearly 20,000 feet long through the rim of the Great Basin. From the tunnel it will be discharged into the Sixth Water Creek and flow thence through Diamond Creek into Spanish Fork River.

7. The project includes the ultimate development of about 3,000 electric horsepower, to be obtained by dropping through penstocks to some of the lower distributing laterals part of the flow diverted at Spanish Fork Dam. The diversion dam and the power canal, which is 3¼ miles long, have been constructed, and 1,200 horsepower is

now being developed. This power development is primarily for use in driving the tunnel, but there is a surplus, part of which is being sold to the town of Spanish Fork.

8. Work on the tunnel is in progress, and about 9,000 feet have been excavated, nearly one-half of the total length. No work has been done upon the storage reservoir nor upon the distribution system.

9. *Engineering structures.*—The Strawberry Tunnel has an arched top. It is 8 feet 6 inches high at the crown, 6 feet 6 inches high at the spring line, and has a width of 7 feet. Its slope is 0.003 and its capacity about 600 second-feet. It is being driven from a single heading at a rate of 400 feet a month. No serious difficulties have been encountered and none are expected. Based upon work already done the cost, including lining, will be about $45 per lineal foot. The Spanish Fork Diversion Dam is of concrete, well constructed and substantial in character. The arrangements, however, for keeping heavy silt out of the canal seem unnecessarily complicated and expensive.

10. *Water supply.*—The run-off of Spanish Fork River at the mouth of the canyon has been measured since 1903, and the amount that could have been diverted to the irrigable area during the irrigation season through the diversion canals as planned is shown in the table below. There is also included in the table such information as is available concerning the run-off of Strawberry Creek (including Indian Creek, which is to be diverted into the storage reservoir):

Years.	Available supply.	
	Spanish Fork.	Strawberry.
	Acre-feet.	*Acre-feet.*
1903	42,000	.....
1904	51,000	54,820
1905	38,500	[1] 40,160
1906	89,500	[2] 84,300
1907	125,500	.....
1908	50,000	.....
1909	125,000	150,000
1910	[3] 72,600	.....
Average	74,262	.....

[1] April 13 to December 31. [2] January 1 to July 12. [3] To September 10.

11. The Reclamation Service has filed on the waters of Spanish Fork, but there are prior appropriations confirmed by court decree which aggregate 350 second-feet, or considerably more than the low-water flow. Under its contract with the Strawberry Valley Water Users' Association, however, these prior water rights will nearly all be merged with those of the United States. Therefore, the maximum amount that can be diverted will be available for the project.

12. On Strawberry Creek a filing was made for 100,000 acre-feet, though the capacity of the reservoir as now proposed is 175,000 acre-feet. This filing expires in January, 1911, and when renewed should, if practicable, be increased. There are no prior rights.

13. *Duty of water.*—The average rainfall on the project is 18 inches, and it is estimated by the Reclamation Service that 2.2 acre-feet per acre additional will be sufficient for agricultural purposes. This

is believed to be reasonable, though less than the average amount now being used on a number of the irrigated farms.

14. The evaporation loss on the reservoir, owing to its position in the mountains, will be slight, and the losses between the reservoir and the diversion weir will also be small. Assuming an evaporation and seepage loss of 25 per cent in the distribution system, 33⅓ per cent will probably cover the total losses on stored water. On this basis, 3.3 acre-feet of reservoir water, or 3 acre-feet of Spanish Fork water, will be required for each acre irrigated.

15. The average run-off of the Spanish Fork River is approximately 75,000 acre-feet, sufficient for the irrigation of 25,000 acres, and the irrigation of the remainder of the outlined project will require 3.3 acre-feet on 35,000 acres, or 115,000 acre-feet from Strawberry Valley. The discharge measurements of Strawberry Creek are so meager that no definite conclusions can be reached as to its ability to furnish the required amount of water. Certainly the data is insufficient to justify the assumption that there will be any greater amount than 115,500 acre-feet.

16. The usable run-off of Spanish Fork Creek can be somewhat increased by the construction of auxiliary reservoirs on Diamond Fork, for which an item of $100,000 is included in the estimate. No surveys have yet been made of these sites, so that neither the amount nor the cost of this auxiliary storage is known. As Diamond Fork Canyon is relatively steep and narrow, the storage will probably be small and the cost per acre-foot relatively high.

17. Based upon the above, it seems probable that there will be sufficient water in ordinary years from the Spanish Fork River and Strawberry Creek for the projection as now outlined, but not sufficient for the irrigation from these sources of any of the proposed extensions.

18. *Lands.*—The irrigable area has an average elevation of 4,500 to 4,800 feet above sea level, and is of good quality, the soil being a sandy and gravelly loam, with deep black soil in the lowlands. Where sufficiently irrigated it produces abundant crops of alfalfa, sugar beets, hay, cereals, and vegetables. Much success has been attained with sugar beets, there being a factory and several slicing stations in the valley. The crop is usually worth from $70 to $75 per acre, with a net profit of from $35 to $40. Parts of the area are devoted to raising fruit and the success thus far attained indicates that a considerable percentage of the area under the project may be suitable for this purpose. Estimates by interested persons place this as high as 60 per cent. There is some trouble with frosts on the fruit lands, especially where there is no air drainage. Near the mouths of the canyons, where there is wind, frost is less likely to occur. In other places owners are compelled to smudge occasionally at a cost of from $8 to $10 per acre.

19. The land used for grain, alfalfa, etc., is worth from $60 to $150 per acre under irrigation. Fruit land with bearing trees has been sold at from $250 to $1,000 per acre, and is said to yield a profit of from $200 to $600 per acre. Land for dry framing is worth from $20 to $40 per acre. In purchasing nonirrigated land for the high-line canal, $40 to $45 per acre was paid.

20. A large part of the land is very low and flat, and the ground water in many places is within from 4 to 6 feet of the surface. Al-

though large areas are at the present time swamped, very little work has been done in the way of drainage.

21. *Cost.*—There has been expended to June 30, 1910, $909,000, and the estimated expenditures to December 31, 1910, are $1,130,000. The estimated additional cost for the completion of the project is as follows:

Storage Dam on Strawberry River, height above foundations, 77 feet	$262,000
Dike between Indian Creek Valley and Strawberry Valley, height above foundation, 35 feet	225,000
Indian Creek diversion. Diversion of all the small streams emptying into Indian Creek, into Strawberry Reservoir	60,000
Completion of Strawberry Tunnel, 10,000 feet of excavation, 15,000 feet of lining, and controlling works east portal of Strawberry Tunnel, gatekeeper's house, etc	695,000
Road to Strawberry Dam and maintenance of tunnel road	25,000
High-line canal, 26 miles long	650,000
Improvements around Spanish Fork diversion dam, and work along power canal	10,000
Siphon and small canal to supply high ground above East Bench Canal	50,000
Rebuilding old canal system, rebuilding old diversion dams, widening old canals, etc	100,000
Distribution system	100,000
Auxiliary reservoirs in Diamond Fork Canyon	100,000
	2,277,000

Making a total cost of $3,407,000, or a cost per acre of $56.80. This unit cost may be considerably reduced should the proposed extensions to be described hereafter prove feasible.

22. At the time the Strawberry Valley Water Users' Association was formed the par value of the shares was placed at $40, which was supposed to represent the building charge. As it now seems probable that the building charge will be considerably higher and as it is questionable whether the land owner can be held for an amount greater than the par value of his stock, unless in making his water-right application he voluntarily assumes the additional obligation, due consideration for the investment of the United States requires that the par value of the stock of the water user's association be increased as provided for in the by-laws. Furthermore, this increase should be made within a reasonable time and prior to any large additional expenditures on the project.

23. There are a number of private and State irrigation projects in the vicinity, the cost of which has varied from $20 to $75 per acre. Considering this fact and the quality of the land in the project, the board believes that, even if the cost amounts to $56.80 an acre, it will not be excessive for fruit land. For other land it will be burdensome but probably not prohibitive.

24. In furtherance of this project 43,000 acres of land, covering practically all of the Strawberry Valley drainage area above Strawberry Dam, was acquired by purchase from the Indian Bureau. This is now leased for grazing purposes at $0.20 an acre a year, and the returns from this source, together with the returns from the sale of surplus electric power, should make the net cost of operation and maintenance low.

25. *Proposed extensions.*—The project as outlined in the last annual report included only 60,000 acres, but recently consideration has been given to a dike and drainage project which would reclaim ap-

proximately 36,500 acres additional. It consists in diking off two arms of Utah Lake, draining these areas by means of pumps, and, during the irrigating season, using the drainage water to irrigate the lands drained. While this extension adjoins the original project and would use power developed in connection with the original project, it is in other respects entirely distinct. The diking off of these two areas was considered by the Reclamation Service in 1904 in connection with what was then known as the Utah Lake projects, and in reference to these dikes a board of consulting engineers then reported:

> Investigations indicate that the material in the bed of the lake is of such character that this plan is not feasible.

26. It is understood that no subsequent examination with a view to finding a suitable site for the dikes has been made. The character of the soil in the bed of the lake is not known. No tests have been made to determine the effect of pumping upon the ground-water levels nor is it definitely known that the drainage water will be suitable for irrigation. Doubt also exists as to whether the ownership of the bed of the lake is in the United States or in the State of Utah. No detailed plans of this extension have yet been prepared, so that the estimate submitted for it, $900,000, must be considered as a mere approximation. Pending the collection of more physical data no opinion can be expressed as to the feasibility of this extension.

27. There has also been under consideration an extension of the gravity system across Santaquin Ridge to include 6,500 acres of public land at the southern extermity of Utah Lake. This is contingent upon a water supply in Spanish Fork and Strawberry Creek more than sufficient for the 60,000 acres in the original project. As this is improbable, the extension does not require further consideration.

28. *Summary.*—(1) The discharge measurements of Strawberry Creek were not sufficient at the time the tunnel was started to warrant so costly an undertaking, and they are not even now sufficient to justify a definite conclusion as to the amount of water that will be available from this source.

(2) The entire area of 60,000 acres under the original project was in private ownership when work was started.

(3) No interstate or international features are involved, the irrigable area as well as the water supply lying within the State of Utah.

(4) Except for the uncertainty as to the water supply, the project is feasible from an engineering standpoint.

(5) Work has progressed so far that due regard for the investment already made requires that the project be completed.

(6) The land can probably bear the building charge, but before any large additional expenditures are made, the members of the water users' association should be required to demonstrate their faith in the project and at the same time guarantee the United States against possible loss by increasing the par value of the stock in their association from $40 to $60 an acre.

(7) Assuming such action by the water users' association, the board believes the project should be completed.

(8) The following allotment is recommended for the four years, 1911–1914, inclusive:

From the loan	$2,272,000

SECTION XXIV.

OKANOGAN PROJECT, WASHINGTON.

1. This project, except the reservoirs which were not visited, was examined by a committee of the board on September 7, 1910, and a public hearing held at Omak on the afternoon of that day.

2. *Location.*—The project, both as to the water supply and irrigable land, lies wholly within the State of Washington. Transportation facilities are poor, the nearest railroad being 50 miles away, and the nearest steamboat line 30 miles away, except for two months each year when the Okanogan River, which bounds the project on the east, is navigable for light-draft boats. The Great Northern Railway is, however, now building a line through the Okanogan Valley which, when completed, will furnish adequate transportation facilities.

3. *Description.*—The project covers 8,650 acres. Water is obtained from Salmon River, a stream which drains about 152 square miles in the eastern foothills of the Cascade Mountains. Flood waters are stored in two reservoirs adjacent to each other, one Salmon Lake with a capacity of 2,000 acre-feet, and the other Conconully Reservoir with a capacity of 13,000 acre-feet. In the latter the water is impounded by an earth dam, 60 feet high. The dam has just been completed and has not as yet been subjected to its full head. A spillway of 5,000 second-feet capacity is provided, which is about ten times the maximum recorded discharge. The outlet is through a reenforced concrete conduit controlled by a cast-iron gate. From the dam the water is discharged into the natural bed of Salmon River and flows thence 12 miles to a small diverting weir. There is a fall of over 800 feet from the outlet of the reservoir to the diverting weir. The canal leading from this weir has a capacity of 100 second-feet. At the end of the second mile it divides into two parts known as the upper main lateral and the lower main lateral, the latter diverting from the main canal through a drop of 105 feet. The upper main lateral also contains a drop of 58 feet at a point one and three-fourth miles beyond the junction. These two drops afford opportunities for the development of power in small quantities which have not yet been utilized. The structures examined were well built and suitable for the purpose intended.

4. *Water supply.*—The run-off of the Salmon River as measured since 1903 is—maximum 56,000 acre-feet, minimum 22,000 acre-feet. In 1908 and 1909 the run-off was less than 30,000 acre-feet and it is probable that the run-off for 1910 will also be less than 30,000 acre-feet. As prior rights on this stream covering 1,350 acres must be satisfied in addition to the 8,650 acres in the Government project, there is need for 30,000 acre-feet every year, the duty of water at the farm being placed at 2 acre-feet and the seepage and evaporation loss at 33 per cent. In 1909 seepage and evaporation losses in the distribution system alone averaged 40 per cent, but these losses will probably decrease with further use of the ditches. It is therefore evident that the capacity of the stream is fully utilized and there probably will be times when less than 2 acre-feet per acre can be delivered at the farms.

5. *Lands.*—The irrigable area within the project is 8,650 acres, of which approximately 1,100 acres were Government land subject to

the provisions of the reclamation act at the time the project was undertaken. The remainder was in private ownership. The average elevation above sea level is 1,000 feet. The average annual rainfall is 8 inches, and without irrigation no crops can be raised.

6. The character of the soil within the irrigable area is volcanic ash, sand, and gravel. It is nearly all suitable for fruit, particularly apples, and is valued at from $100 to $300 per acre. About 4,000 acres of the 8,650 in the project received water this year, and it is probable that 70 per cent of the total will be under irrigation in 1911.

7. *Cost.*—The cost of the project to June 30, 1910, was $573,000, and the estimated cost of completion at that date $17,000, a total of $590,000. The building charge was fixed in 1908 at $65 per acre, except as to 499 acres, which were allowed credits of from $6 to $10 per acre in consideration of the owners constructing their own ditches and carrying devices. The anticipated returns are $558,304, so there will be a loss to the reclamation fund on this project of about $32,000, nearly $4 per acre. The charge for operation and maintenance in 1909 was $1.50 per acre. There is also a deficit under this heading due to the small acreage under cultivation, but it is expected that this will be made up in subsequent years.

8. *Extensions.*—The project as outlined by the Reclamation Service has been practically completed, but request is made by the Okanogan Water Users' Association for an extension primarily for the purpose of increasing the size of the irrigable area and thereby reducing the cost of operation and maintenance per acre. Two extensions have been considered, one to utilize part of the power now going to waste between the storage dam and the diversion weir, or the power that can be developed at the two drops and transmit it electrically to a point on the Okanogan River, and there pump water from the Okanogan River to lands adjacent to the left bank of the river and within the Colville Indian Reservation. Another suggestion is to increase the size of the upper main lateral between the two drops and continue it at the high level beyond the 58-foot drop. To provide water for this purpose it is proposed to utilize part of the water now dropped into the lower main lateral and to substitute for the water so withdrawn water pumped from the Okanogan River, utilizing power to be developed either at the drops or in Salmon River above the diversion weir. The areas covered by the proposed extensions consist of good fruit land, equal and probably superior to the low-lying areas under the existing project.

9. The cost of the extension to the Indian lands on the left bank of the Okanogan has been approximately estimated by the Reclamation Service at somewhat less per acre than the cost of the existing project. No estimate has been made of the cost of irrigating the land between the upper main lateral and Johnsons Creek, but judging from the superficial examination made it would be in excess of $65.

10. Statements were made by interested persons that a building charge up to $100 per acre would not be prohibitive, so there is no doubt but that all of the land under the extensions will be able to carry the construction charge. The proposed extensions are also feasible from an engineering standpoint.

11. None of the land under consideration is public land subject to homestead entry, though that on the east bank is unallotted Indian land.

12. *Summary.*—(1) The Okanogan project lies wholly within the State of Washington.

(2) As constructed it is feasible from an engineering standpoint, is practically completed, and the land can readily pay the construction charge placed upon it.

(3) The total cost will be approximately $590,000.

(4) The announced building charge, $65 per acre, is not sufficient to insure full returns to the reclamation fund, the estimated loss being $32,000.

(5) The proposed extensions are feasible from an engineering standpoint, and the probable cost per acre will be well within what the land can stand.

(6) As there is no land under these extensions subject to homestead entry, it is not advisable to undertake either of them with reclamation funds.

(7) If the Okanogan Water Users' Association desires to do this work at its own expense it should be encouraged to do so.

(8) The following allotment is recommended for the four years, 1911–1914, inclusive:

From the fund	$13,000

Section XXV.

YAKIMA PROJECT, WASHINGTON.

1. The board inspected this project from August 29 to September 1, inclusive, and held public hearings at Sunnyside, North Yakima, and Ellensburg. The examination included the proposed additional units, as well as those under construction. All the principal structures and the sites of those proposed were visited either by the board as a whole or by committees of its members.

2. *Location.*—The project both as to water supply and irrigable area lies wholly within the State of Washington. With the exception of the Benton unit, which lies in the Columbia Valley, all the irrigable area is in the valley of the Yakima River, upon which river with its tributaries it depends for the necessary supply of water. North Yakima is the principal city within the project. The main line of the Northern Pacific Railroad passes through the entire valley, affording with its branches adequate transportation facilities. These are supplemented by the Chicago, Milwaukee & Puget Sound Railroad, which passes through Ellensburg in the Kittitas unit, and by the North Coast Railroad, now under construction in the lower valley.

3. *Description.*—This project as outlined contemplates the irrigation of over 400,000 acres of land, divided into a number of distinct units. While these units are in a measure independent of each other, they are, with the exception of the Tieton unit, all dependent upon a common system of storage reservoirs and by formal order of the Secretary of the Interior, March 3, 1909, were consolidated into one project.

4. On two of the units, the Sunnyside and the Tieton, work is now in progress, the former being 60 per cent complete and the latter 80

per cent complete. No work has been done on the Kittitas and Wapato units beyond the preparation of preliminary plans and estimates of cost. On the Benton unit no work has been done except a preliminary reconnaissance in 1905.

5. A sixth unit, known as the High Line, has recently been proposed by private interests and has been made the subject of investigation by the Reclamation Service.

6. *Water supply.*—Before work on the Yakima project was undertaken by the Reclamation Service the low-water flow of the Yakima River was overappropriated and there were many conflicting claims. As a precedent to beginning work in the valley it was required that these conflicting claims be settled. This was done by limiting agreements entered into by the users of water whereby the aggregate amount of the claims was limited to approximately the low-water flow. These agreements do not have the binding force of a court decree, but will probably serve as the basis of an adjudication should one be made in the future. In addition the State legislature by enactment made it possible for the Reclamation Service to withdraw from further appropriation all the unappropriated waters of the watershed, thus permitting a maximum development. This control of the unappropriated run-off is dependent upon continuous progress of construction and upon beneficial use of water.

7. As the development of this project depends primarily upon the storage of flood water, five reservoir sites have been selected, the capacities of which are given in the following table. The first three of these are at the headwaters of the Yakima River and the last two at the headwaters of the Naches River, one of its tributaries:

Reservoir sites.	Capacity.	
	Present.	Ultimate.
	Acre-feet.	*Acre-feet.*
Lake Cle Elum	23,000	426,000
Lake Keechelus	15,000	142,000
Lake Kachess	56,000	210,000
McAllister's meadow	.....	115,000
Bumping Lake	35,000	35,000
Total	129,000	928,000

8. The present capacity of the reservoirs is only sufficient to meet existing requirements on the Sunnyside and Tieton units. It will be gradually increased as further work on the irrigable areas is undertaken.

9. The water shed of the Yakima River has an area of 5,050 square miles and an average annual run-off of 3.000,000 acre-feet. A comprehensive study of the hydrographs of this river at different points during the period of 1904–1910 has been made by the Reclamation Service. Against the discharge curves has been plotted the demand curves for the different units and the storage requirement determined for each year, due allowance having first been made for prior rights. The results of this study are appended to this report and show the proposed storage in connection with flood flow to be sufficient for the irrigation of 417,000 acres. If to this be added the 64.000 acres in the Sunnyside and Wapato units, to which low-water rights attach,

the total area capable of irrigation becomes 481,000 acres. In the following table are listed the acreages assumed in this study and the corresponding storage requirements:

Project.	Total acres under project.	Acreage requiring storage.	Storage charge (acre-feet).	Cost of storage, assuming full development and uniform distribution.
Kittitas	67,000	67,000	146,000	$654,000
Benton, or High Line	160,000	160,000	366,000	1,638,000
Tieton	34,000	34,000	59,000	264,000
Wapato	129,000	108,000	247,000	1,106,000
Sunnyside	100,000	48,000	110,000	493,000
Total	481,000	417,000	928,000	4,155,000

The assumptions upon which the analysis was made appear to be reasonable and the conclusions justifiable.

RESERVOIRS.

10. *Cle Elum Lake Reservoir* is on the Cle Elum River about 7 miles above its confluence with the Yakima. The average annual run-off at this point is 575,000 acre-feet. A temporary crib dam built in 1907 affords capacity for 23,000 acre-feet. It is proposed to develop an ultimate capacity of 426,000 acre-feet by the construction of an earth-fill dam at the outlet of the lake, with concrete outlet works and spillway. The foundations are suitable for such a dam, and satisfactory material for its construction can be obtained in the vicinity.

11. *Keechelus Lake Reservoir* is near the source of the Yakima River, the average annual run-off at this point being 200,000 acre-feet. A temporary crib dam built in 1907 affords capacity for 15,000 acre-feet. It is proposed to develop an ultimate capacity of 142,000 acre-feet by the construction of an earth-fill dam at the outlet of the lake, with a concrete outlet conduit and controlling works and concrete lined spillway. The foundations are suitable for such a dam and satisfactory material for its construction can be obtained in the vicinity. Final plans for this dam have not yet been made.

12. *Kachess Lake Reservoir.*—This lake lies between Keechelus Lake on the west and Cle Elum Lake on the east, the dam site being only 3 miles from the railroad. The lake has a drainage basin of only 63 square miles, but the average run-off since 1904 has been 208,000 acre-feet. A temporary crib dam, constructed by a private company, whose rights have since been acquired, provides storage for 16,000 acre-feet. During the past year this has been increased by the construction of a drainage channel, enabling the lake to be lowered and thereby increasing its capacity to 56,000 acre-feet. It is proposed to develop an ultimate capacity of 210,000 acre-feet partly by increasing the depth of the drainage channel and partly by the construction of a permanent earth dam of greater height than the existing crib dam. The plans include a spillway with a capacity equal to the greatest flood of record—7,200 second-feet—but as the reservoir provides for storing the maximum run-off, and as maximum

floods usually occur when the reservoir is at its low stage, the spillway will, probably, not often be required.

13. *McAllister's Meadow Reservoir.*—The site of this reservoir is on the headwaters of the Tieton River and has an estimated capacity of 115,000 acre-feet, about one-third of the average annual run-off at this point. This site was examined by a committee of the board and its report thereon is appended. The dam site is suitable for the character of dam proposed and the general plan as outlined is feasible, though probably at greater cost than is given in the estimates.

14. *Bumping Lake Reservoir.*—This reservoir is situated at the headwaters of the Bumping River, a tributary of the Naches River, about 46 miles from Naches. The reservoir has a capacity of 35,000 acre-feet and the run-off above it is more than sufficient to fill it each year. The reservoir is formed by an earth-fill dam now under construction and nearing completion. The report of a committee of the board which examined it is appended. In this report attention is invited to inferior concrete in the spillway, and to the material used and slopes adopted. It is believed that additional work on the dam may be necessary.

15. The ultimate capacity, estimated total cost, and cost per acre-foot of the different reservoirs are tabulated below:

Sites.	Ultimate capacity (acre-feet).	Already expended or allotted.	Additional allotment required.	Estimated total cost.	Ultimate cost per acre-foot.
Lake Cle Elum	426,000	$48,834	$1,050,000	$1,100,000	$2.58
Lake Kecchelus	142,000	44,955	850,000	895,000	6.30
Lake Kachess	210,000	138,000	574,000	703,000	3.35
McAllister's Meadow	115,000	32,654	900,000	932,000	8.10
Bumping Lake	35,000	525,000	.....	525,000	15.44
Total	928,000	789,443	3,374,000	4,155,000	.....

SUNNYSIDE UNIT.

16. *Location and description.*—This unit lies in Yakima and Benton Counties and is based upon a private canal known as the Sunnyside, which possessed one of the oldest and largest water rights in the valley, amounting to 1,050 second-feet. Only 650 second-feet was being beneficially used at the time of its acquisition, and in the limiting agreements as to prior water rights, referred to above, the Sunnyside Canal is accorded this amount. This canal with its appurtenances was purchased in 1906 for $250,000. Water is diverted from the Yakima River just below Union Gap by a concrete diversion dam built by the Reclamation Service to replace an old crib dam. It is 7 feet high and rests on a rock foundation. The main canal, which is to be about 60 miles long, is now being enlarged to a maximum capacity of 1,076 second-feet. Other improvements undertaken by the Reclamation Service were:

(*a*) The construction of concrete drops in the main canal, the original slope being too steep to admit of enlargement without danger of excessive erosion.

(*b*) The construction of additional culverts for the better protection of the main canal against storm waters.

(*c*) Reconstruction of turnouts, substituting concrete for wood.

(*d*) The construction of three wasteways, which also serve as main drains for low-lying areas. The most important of these is the Sulphur Creek wasteway, 37 miles from the headworks, designed to carry the full flow of the canal at that point—515 second-feet.

(*e*) The construction of the Mabton siphon across the Yakima River designed to water about 10,000 acres on the right bank of the Yakima River in the vicinity of Mabton.

17. *Water supply.*—The water rights acquired in the purchase of the Sunnyside Canal are insufficient for more than 5,200 acres and must be supplemented by storage. From the hydrographs of the river the storage required has been determined at 110,000 acre-feet.

18. *Lands.*—The irrigable area is about 100,000 acres, of which 1,346 is public and the remainder private land. The average elevation of the irrigable area is 700 feet above sea level, and the average rainfall 7 inches.

19. The soil is deep volcanic ash and gravel. Without irrigation farming is not possible. When irrigated the soil is very productive, the principal crops being forage, hops, vegetables, and fruits. About one-half of the area under the project is now being irrigated and water will be available for 12,400 acres additional by December 31, 1910. Of the area under cultivation the largest part is used for raising hay and alfalfa. The higher lands are devoted to fruit and yield abundant crops of peaches and apples.

20. The average value of lands under irrigation varies from $200 for alfalfa lands to $500 for fruit lands. The average returns from irrigated land, as stated by the residents in this unit, are large, and it can readily bear the construction charge. Considerable areas under this unit have been rendered temporarily useless by alkali, due to subirrigation. The first step to remedy this condition has been taken in the construction of the Sulphur Creek wasteway, which is to serve also as the main drain for the Sunnyside Basin. The cost of this main drain is charged against the unit as a whole. The cross drains leading to it, which will be necessary to fully reclaim the alkali lands, are to be constructed by the owners of the land directly benefited. The Granger Basin in this vicinity is also in need of drainage, and preparatory surveys have been made.

21. *Cost.*—The expenditures on this unit to June 30, 1910, including storage, were $1,443,000, and the estimated cost of completion, exclusive of storage, is $1,205,000. This cost of completion includes $388,000 for pumping plants, the cost of which is to be repaid by the lands to which the water is pumped in addition to the regular construction charge. The estimated cost of storage is $500,000, making the total cost $3,148,000.

22. *Returns to the reclamation fund.*—Under the terms of agreement by which the Sunnyside Canal was acquired, 3,080 acres was to be provided with water free of charge and the remainder of the land under the canal was to bear no construction charge but an annual operation and maintenance charge of $1 per acre. These lands, however, had no right to stored water and to put them on a parity with new lands irrigated under this unit, the owners of the old lands were permitted to purchase a supplementary water right at cost of $10 per acre. This not only entitled them to share in the benefits of the storage system but entitled them to operation and maintenance at actual cost instead of at a fixed sum of $1 per acre. This unit also includes

1,108 acres of land at Prosser, which, owing to prior partial development, is to bear a construction charge of $31 per acre. The remainder of the irrigable area, 52,913 acres, is to bear a construction charge of $52 per acre. The estimated returns slightly exceed the estimated expenditures.

23. *Comments.*—Less than 2 per cent of the land under this unit is public land subject to homestead entry, but the expenditures already made are so largely in excess of the returns that would be received from the areas now irrigated that a continuation of the work is desirable at least to an extent sufficient to insure the return of the investment.

24. The proposed extensions of the Sunnyside unit include four pumping plants to be operated electrically, power being developed at a number of different drops in the distribution system. These pumping plants are designed to cover 14,310 acres of land, the water being pumped from laterals supplied through the main canal. The cost of these pumping plants is to be borne by the land irrigated by them, and in addition these lands must pay the regular construction charge for this unit of $52. As 85 per cent of the land to be thus irrigated is in private ownership, it would seem to be advisable to leave the installation of the pumping plants to the owners, the United States merely delivering water to the pumps and receiving therefor the regular construction charge. Such an arrangement while desirable is contingent upon the passage of a law providing for the sale of surplus water.

TIETON UNIT.

25. *Location.*—This unit, containing 34,500 acres, lies on the right bank of the Yakima River between the Naches River and Atanum Creek. It is all within 20 miles of North Yakima and is served by the North Yakima and Valley Railroad and by an electric line.

26. *Description.*—Water for this unit is taken from the Tieton River about 15 miles above its confluence with the Naches River. The system consists of a concrete overflow diversion dam founded on rock and rock-filled cribs, concrete headworks, a concrete lined main canal 12 miles long with a capacity of 330 second-feet, and a system of distributing laterals diverting from the North Fork of Cowiche Creek, into which the main canal empties.

27. The main canal is lined with concrete throughout the entire length of 12 miles, except for a short distance below the intake. It is built through a rough country and 2 miles of it are in tunnel. Concrete wasteways, approximately 2 miles apart, are provided and are intended to operate automatically. Each is capable of discharging the entire flow of the canal, a condition deemed necessary owing to the danger of stoppage or breakage by rocks rolling down the canyon side.

28. The distributing system for the first subdivision of 11,000 acres has been completed and that for the second subdivision of 9,000 acres is under construction. No work has been done upon the third subdivision, covering the remainder of the area, except the preparation of plans and specifications.

29. The distribution system in the Tieton unit provides for delivering water to each 40-acre tract, and since much of the area is broken or undulating, flumes and pipe lines have been freely used. On the

main laterals the flumes are of steel (Maginis type) with timber substructures, and on the sublaterals all timber. The pipe line sublaterals are of cement and wood stave pipe 6 inches to 24 inches in diameter. Eleven miles of flumes and 53 miles of pipe line are constructed or contemplated.

30. All the structures on this unit are well built and suitable for the purpose intended. All are of a permanent character except the wooden flumes. The latter, were estimated to cost less, including repairs and renewals, than if built of more durable material.

31. *Water supply.*—Pending the construction of McAllisters Meadow reservoir, this unit will be dependent upon the unregulated flow of the Tieton River. Measurements since 1900 indicate that the Tieton low water will be taxed to its capacity to supply water for the Tieton project and that full development may require some storage on this river.

32. To satisfy prior water rights below the diversion dam, all of which, except 5 second-feet, are in the Lower Naches and Yakima valleys, the water diverted from the Tieton during the low water flow will be replaced in the Naches River from the Bumping Lake Reservoir. If McAllisters Meadow reservoir is constructed the Tieton unit will draw on this reservoir, leaving the appropriated water of the Tieton undisturbed, and Bumping Lake reservoir a part of the general storage system.

33. *Lands.*—The average elevation of the irrigable area is 1,700 feet above sea level and the average rainfall 9 inches. Dry farming is impossible. The irrigable area is 34,500 acres of which less than 6 per cent is public land subject to the reclamation act.

34. The soil is volcanic ash, in places underlaid with hard pan, and much of the first subdivision is rough and broken. Nearly all of the land in this unit is suitable for fruit. Based on the character of the soil and on the crops that will probably be raised, the duty of water is assumed at 2.17 acre-feet per acre on the land, while on the Sunnyside unit 3 acre-feet per acre are provided for. This duty of water will require economic use. One thousand six hundred acres of land in the first subdivision were partially irrigated from flood flow this season.

35. The land in private ownership has been divided into tracts ranging from 10 to 80 acres and is being sold at prices varying from $125 to $175 per acre, the purchaser paying the construction charge in addition thereto. Before the Government took up this project the land was practically valueless.

36. *Cost.*—The total expenditures, including liabilities, to June 30, 1910, and exclusive of storage, amounted to $1,720,000, and the expected expenditures to December 31, 1910, will bring this total up to $2,000,000. Approximately $660,000 will be required after that date to complete the unit.

37. If to this amount is added the cost of the Bumping Lake storage—$525,000—the total estimated cost will be $3,185,000, or about $93 an acre. This may be somewhat reduced, if the entire project, as outlined, is constructed and the total cost of the common storage system divided among the different units in proportion to their needs of stored water.

38. The land in the Tieton unit is not all equally good nor all suitable for fruit. Fruit land can readily bear the construction charge. For other land, the charge will be high, but probably not prohibitive.

39. The par value of the stock in the Water Users' Association is $60 a share. As it is questionable whether the land can be held for any greater amount, unless in making their water applications the owners voluntarily assume the added obligation, due regard for the investment already made requires that the par value of said stock be increased, as provided in the by-laws of the association, to not less than $93 a share.

40. The project is feasible from an engineering and economic standpoint, and though the direct interest of the United States is small, due to the limited amount of public land, early completion is desirable in order that the investment already made may be returned to the reclamation fund.

KITTITAS UNIT.

41. *Location.*—The proposed Kittitas unit lies in the Upper Yakima Valley in the vicinity of Ellensburg and partially surrounds an area now under irrigation by private canals. Some of these canals receive water from the Yakima River and some from small creeks.

42. *Description.*—This unit was first investigated in 1905, and because of the relatively high cost and the relatively low value of irrigated land at that time, its feasibility was considered doubtful. In 1909 careful preliminary surveys were made and estimates prepared based on the following general plan:

43. A diversion dam is to be built on the Yakima River above Easton with a 500 second-foot canal heading on the right bank and running down the valley 32 miles. At this point the flow is to be divided, the greater part being carried over the river and railroads in a wood stave pipe supported on truss bridges. From the crossing to the irrigable lands the canal is to follow the left bank of the river.

44. *Water supply.*—Water is to be obtained partly from the flood flow of the river and partly from storage taken from the general reservoir system. The storage charge for this unit is 146,000 acre-feet.

45. *Lands.*—There are 67,890 acres in this unit, of which less than 7 per cent is public land subject to the reclamation act. One-third of this area now has a partial water right from creeks estimated at 25 per cent of a full water right. If these lands pay only 75 per cent of the construction charges the returns to the reclamation fund will be equivalent to full returns on 62,000 acres.

46. The average elevation of the irrigable area is 1,600 feet above sea level, and the average rainfall 10 inches.

47. The higher lands under this unit are volcanic ash underlaid with hardpan. The lower lands have more gravel.

48. The duty of water is placed at 25 inches. This seems to be low and will require economical use.

49. The main produce of the area now irrigated is hay, with some fruit and vegetables. Much of the land in the proposed unit lies higher than that now irrigated, and 40 per cent of it is considered good fruit land, while the remainder seems better adapted to hay or alfalfa.

50. Hay land is said to be worth $200 an acre. Fruit land will be worth much more.

51. *Cost.*—The estimated cost of this unit is $4,525,000, which includes $527,000 for storage. This is equivalent to $73 an acre. As the cost of storage is likely to be greater than that assumed above, the unit cost may be $75 an acre.

52. This cost is nearly 50 per cent greater than on the Sunnyside unit, but from statements made to the board by interested persons, it is believed that the land can bear the charge.

53. The project does not involve any unusual engineering difficulties, though the main canal is expensive and for part of the distance passes through difficult country. While this unit has by Executive order been made a part of the Yakima project it is essentially a new project. It contains less than 7 per cent of public land and large expenditures will be necessary before any part of the unit can be irrigated. For these reasons, together with the need of available funds for the completion of projects in which the Federal interests are larger, it does not seem advisable to undertake the irrigation of this unit except to create and furnish the necessary stored water, should the sale of surplus water be authorized by law.

WAPATO UNIT.

54. *Location.*—The proposed Wapato unit lies on the right bank of the Yakima River, just below Union Gap, and consists of land at one time allotted to members of the Yakima Tribe of Indians. Of the 114,000 acres in the project, about 7.000 acres are now owned by white settlers and about 24,000 acres additional is under lease to white settlers. About 32,000 acres are now partially irrigated, 27,000 being Indian allotment land and 5,000 acres being in white ownership. The existing canals were largely built by the Indian Service, which began work in 1903, though several small ditches had been constructed prior to that date.

55. *Description.*—A preliminary allotment for this unit was made in 1906, but no construction work has yet been undertaken. Two plans for irrigating this area have been considered. One provides for an enlargement of the existing New Reservation Canal sufficient to carry all the water needed, and the construction of a diversion dam at its head; the other provides for partial diversion at this point without the aid of a dam and the diversion of the remainder and larger part at the Sunnyside Dam. The first permits of a larger power development. Estimates based on existing information show little difference in cost. Under either plan 100,000 acres will be irrigated by gravity and 14,000 acres by pumping. The main laterals are designed to follow the contours on proper grade, with sublaterals on each section line and sufficient branches to reach each 80-acre tract. An adequate system of drains is also provided for.

56. *Water supply.*—At the time the water rights in this valley were settled by limiting agreements, 147 second-feet were being beneficially used on this reservation, and the Secretary of the Interior at that time limited the rights of the Yakima Indians to that amount. As the total amount of water that will be required for full development is 1,425 second-feet, approximately 1,278 second-feet must be furnished from storage during the season of low water. This

amount with an allowance for losses in transmission is provided for in the study of the water supply of the valley.

57. *Lands.*—The average elevation of the irrigable area is 850 feet above sea level and the average rainfall 7 inches. On the higher lands the soil is volcanic ash and on the lower lands a sandy loam with loose gravel subsoil. The duty of water is placed at 3.6 acre-feet per acre and is made higher than on the Sunnyside unit because of the loose gravel subsoil over the greater part of the area. The high lands will be valuable for fruit raising, while the low lands are better adapted to raising hay and potatoes, though good fruit has been raised on limited areas of low land.

58. Unimproved land has been sold at from $100 to $165 an acre, and land with fruit trees 4 years old as high as $500 an acre.

59. In constructing the existing ditches sufficient care was not taken to keep them above the underlying stratum of gravel. As a result the lower end of the irrigated area is now badly swamped and in need of drainage. An appropriation to do this work was recently made by Congress, and preliminary steps have already been taken.

60. *Cost.*—The estimated cost, exclusive of storage, is $3,100,000, and the storage charge about $1,105,000, making the cost per acre nearly $37. It is understood that this includes payment to the Yakima Indian fund for the irrigation works heretofore constructed.

61. *Comments.*—The irrigation of this unit is practicable from an engineering standpoint, and the land is of such character that it can bear the construction cost.

62. Under the Jones Act of March 8, 1906, the Indian allottees are permitted to dispose of all land in excess of 20 acres, the proceeds to pay for the irrigation of the area retained. The same act also authorizing the homesteading of any irrigable surplus or unallotted lands, but it is understood that there are no such lands in this unit.

63. While all the land involved is in private ownership, most of the present owners are Indians who are still the wards of the nation. As long as this condition exists the irrigation of this area in a comprehensive manner by private enterprise is impossible. For this reason it is believed to be advisable for the United States to undertake this work when funds become available.

BENTON UNIT.

64. This proposed unit includes from 120,000 to 150,000 acres of land on both sides of the Yakima River near its junction with the Columbia. This unit has never been surveyed, and while a reconnoissance made five or six years ago showed in a general way its possibilities, the cost of irrigation per acre can not be definitely stated. Adjoining lands both on the north and south sides of the Yakima River are now being irrigated from private ditches, and excellent results are being obtained. Lands under these private ditches near Kennewick are held at from $300 to $500 per acre, including water right. As the lands under the proposed Benton unit are as good or better than those now being irrigated, it is believed that they can bear any reasonable construction charge. Included in this unit are approximately 50,000 acres of Government land subject to entry under the reclamation act, a larger percentage of Government land than in any other unit under the Yakima project.

65. The original plan for irrigating the Benton unit was to divert water from the Yakima River near Prosser, carry it down the valley to a point some 32 miles below, and there divide the canal into two branches, the larger leading to the lands in the Columbia River Valley above the mouth of the Yakima, and the smaller by siphon across the Yakima River to the lands near Kennewick. A second method is included in the plans of the Valley of the Yakima Water Users' Association, which recently submitted a proposition looking to the purchase from the United States of stored water, to be used in the reclamation of 200,000 acres on the left bank of the Yakima River above existing canals. This request is made contingent upon the passage by Congress of an act authorizing the sale of stored water.

66. If this proposition is accepted, the reclamation of the Benton unit by water from the Yakima River would have to be abandoned, as the supply would not be sufficient for both the Benton unit and the area named in the application of the Valley of the Yakima Water Users' Association. To meet this objection, it is proposed to utilize the power developed at certain drops in the proposed high line to pump water from the Columbia River on to 100,000 acres of the Benton unit lying north of the Yakima River. The proposed high line provides for the use in the Yakima Valley proper of all the storable water of the Yakima River, leaving the Benton project, which geographically belongs in the valley of the Columbia, to be watered from the Columbia River.

67. This plan interferes somewhat with the proposed Kittitas unit in that the acreage under it will have to be reduced. The Benton unit will also have to be reduced, and the cost of placing it under irrigation, as well as the subsequent cost of operation and maintenance, will be largely increased.

68. The high-line plan was advocated generally by the residents of the upper valley and opposed by those in the vicinity of Kennewick, who claim that in the adjustment of low-water rights concessions were made on the assumption that the Benton project as originally outlined would be carried out.

69. The data available are not sufficient upon which to base a definite opinion as to the feasibility of the high line either from an engineering or economic standpoint.

70. Even if found to be feasibile, its advisability is questionable, as it will probably add 75 per cent to the cost of irrigating the public land in the Benton unit and probably double the cost of operation and maintenance. As the primary object of the reclamation act is the irrigation of public lands, the interests of the Government would seem to lie in irrigating the Benton unit in the cheapest possible manner, though, on the other hand, it may be advantageous to sacrifice the interests of the United States in its own lands for the good that may result to the Yakima Valley as a whole.

SUMMARY.

1. The entire project, both water supply and irrigable land, lies within the State of Washington.

2. As outlined, it covers 481,000 acres of land, of which 13 per cent is public land subject to the reclamation act. All but 13,000 acres of this public land lies in the proposed Benton unit.

3. The water supply as regulated by the proposed reservoir system is sufficient for the above acreage if the assumed duty of water on the different units proves to be sufficient. There is an assured supply for the Sunnyside, Tieton, and Wapato units herein recommended.

4. The Sunnyside unit contains 100,000 acres, of which 1,346 acres are public land subject to the reclamation act. It is feasible from an engineering and economic standpoint. The estimated total cost is $3,150,000, the unit cost being $52 an acre. Sixty per cent of the work has been done and due regard for the investment already made renders its completion advisable, except possibly the pumping plants. If authority is granted by Congress for the sale of surplus water it may be advantageous to leave the installation of the pumping plants to private enterprise, as only 15 per cent of the land involved is public land.

5. The Tieton unit contains 34,500 acres, of which 2,034 acres are public land. It is feasible from an engineering and economic standpoint. The estimated total cost is $3,185,000, the unit cost being $93 an acre. Eighty per cent of the work has been done. In order that the investment already made may be returned to the reclamation fund its completion is advisable. Such action, however, should be contingent upon the water users' association first increasing the par value of its stock to not less than $93 an acre.

6. The proposed Kittitas unit contains 67,000 acres, of which less than 7 per cent is public land. It is feasible from an engineering and economic standpoint. The estimated cost is $4,600,000, the unit cost being $75 an acre. Owing to the limited amount of public land and the large amount of uncompleted work on other projects where the Federal interests are larger, it is not advisable to undertake the Kittitas unit except to supply the necessary stored water should this course be authorized by law.

7. The Wapato unit contains 114,000 acres of land all in private ownership. Most of the owners, however, are Indians whose lands can not be disposed of without the consent of the United States. It is feasible from an engineering and economic standpoint. The estimated cost is $4,205,000, the unit cost being $37 an acre. While there is no public land in the strict sense of that term, most of the private owners are wards of the nation, and for this reason it is advisable to undertake the irrigation of this area when funds become available.

8. Information concerning the Benton unit is too meager to warrant a definite opinion as to its feasibility. Even if found to be feasible, its development can advantageously be postponed pending the completion of work on the Sunnyside, Tieton, and Wapato units. Surveys, however, should be made to determine the probable cost of irrigating it by gravity from the Yakima River.

9. The proposed High Line as a private enterprise is dependent upon the United States furnishing stored water for which there is no present authority of law. The estimated cost of the High Line is $26,000,000, and it is extremely doubtful whether the necessary capital can be raised for an irrigation enterprise of this magnitude; nor with the great demand for funds on other projects, involving public

land, is it advisable for the United States to undertake this work with reclamation funds. Further, until the cost of irrigating the Benton unit, in accordance with the original plans, is ascertained, it is recommended that no action be taken that will obligate the Reclamation Service to furnish stored water for the High Line project.

10. A general system of storage in this valley should be developed and controlled by some central power, even though the delivery of water to the land in some of the units is left to private capital. Due to the large interests of the United States in this valley, both by reason of expenditures already made, as well as those herein recommended, a storage system as now planned should be developed with reclamation funds at a rate that will keep pace with the demand.

11. The following allotments are recommended for the four years 1911–1914, inclusive:

For Sunnyside unit (from the loan)	$1,250,000
For Tieton unit (from the loan)	665,000
Total	1,915,000

Section XXVI.

SHOSHONE PROJECT, WYOMING.

1. On August 10 the board inspected the Shoshone Dam and water-storage system; on August 11 the lands under the high line and Garland-Frannie Canals, the Oregon Basin, diverting dam, tunnel, reservoir, canals, laterals, and other constructions. A public hearing was held at Cody, Wyo., on the evening of August 10.

2. *Location.*—The lands to be irrigated lie on both sides of the Shoshone River in northern Wyoming, east of Yellowstone Park. The water is taken from the Shoshone River, a branch of the Big Horn River, just below the junction of the north and south forks. The land and water supply are entirely within the State of Wyoming. The general elevation is about 4,500 feet. A branch of the Chicago, Burlington & Quincy Railroad passes through the north-side lands.

3. *Description.*—The project as proposed and partially constructed consists of a large dam and storage reservoir in the Shoshone Canyon and of the diverting systems, tunnels, main canals, and laterals.

4. The dam is practically completed. It is 328.4 feet above the lowest point of foundation, the width at bottom 108 feet, at top 10 feet, length at top 200 feet, radius of center line at top 150 feet. There is a spillway 300 feet long, discharging through a tunnel 20 feet square and 400 feet long, excavated in granite; and the discharge is regulated by tunnels and pipes at different elevations. The dam is constructed of concrete in which large bowlders are embedded. In case additional storage or additional head proves desirable, it is proposed by the Reclamation Service to increase the height of the dam. The cost of the dam to June 30, 1910, was $978,466.01, at which time the dam was almost completed. These items do not include cost of lands overflowed, amounting to $184,458.23, nor the cost of the canyon road, $105,191.51, necessary to the construction of the dam.

5. The distributing system, as projected, consists of three main canals, as follows:

(*a*) The high-line canal starting at the reservoir, irrigating lands lying north of the river in the general vicinity of the towns of Cody, Corbett, and Eagle Nest. No work has been done on this canal.

(*b*) The Garland-Frannie Canal, irrigating land on the north side of the river from the town of Ralston to Frannie. Water for the Garland-Frannie unit is diverted at a point on the river 15 miles below the reservoir by the Corbett Dam, a concrete structure 400 feet long and 18.1 feet high. The water is then carried in a concrete-lined tunnel, 17,355 feet long with a capacity of 1,000 second-feet, and emptied into a basin formed by closing a natural depression with an earth dam. At this point begins the main Garland-Frannie Canal, which has a capacity of 1,000 second-feet and is completed for a distance of 18 miles. At about 7 miles from its head it passes through the Ralston reservoir, which serves to equalize the flow and will probably also serve as a source of water supply for the town of Ralston. It is expected that about 1,000 horsepower may be developed on this canal. This unit is about 75 per cent completed.

(*c*) The Willwood Canal, irrigating lands south of the river, will take water by a diversion dam or other means at a point about 21 miles below the reservoir. No work has been done on this canal.

6. *Water supply.*—The run-off of the Shoshone River above the dam is relatively uniform as far as records go, and varies from 975,000 to 1,506.000 acre-feet per annum. The storage reservoir will impound 456,000 acre-feet. As the irrigation season includes the times of maximum run-off, practically the entire flow can be used for irrigation. On the basis of a duty of 3 acre-feet at the reservoir and 2 acre-feet at the farm, 344,000 acres could be irrigated, including private irrigation projects. There are a number of private filings on the unregulated flow of this river, some antedating and some subsequent to those of the United States. There are no private filings on the storage water and practically none on the North Fork, which carries double the water of the South Fork. It seems assured that there is sufficient water to irrigate the 164,000 acres of land included in this project. A discussion of the water rights and filings is appended. The duty of water is taken as 2 feet at the farm. This is thought to be sufficient.

7. *Land.*—The total amount of irrigable land included in the project is given in the annual reports at 132,000 acres, of which 123,000 acres are public, 7,680 acres State and school, and 1,220 acres private land. The public land will not be opened to settlement until water is available. The land has not been completely surveyed, and the assumed amount of irrigable land is therefore approximate. In a recent statement of the supervising engineer, based on later surveys and relocation of some of the canals, he estimates the total amount of irrigable land in the project at 164,000 acres, including 7,500 acres to be supplied by pumping from the high-line canal. The proportion of public land is about the same.

8. In 1899 Col. W. F. Cody and Mr. Nate Salisbury prepared for the irrigation, under the Carey Act, of land lying on the north bank of the river immediately below the canyon, and applied for water to irrigate 120,000 acres. This was subsequently limited by the State

engineer to about 65,000 acres. No constructions were made, and in 1904 all water rights were transferred to the United States.

9. Under the high-line unit there are 36,500 acres to 40,000 acres, under the Garland-Frannie unit 73,000 acres to 86,622 acres, and under the Willwood unit 22,500 acres to 30,000 acres. Under the completed part of the Garland-Frannie Canal 30,989 acres have been opened to settlement and about 3,200 acres near Ralston can be thrown open within a few months. Of this area, about 15,000 acres have been filed on and were under cultivation this year, leaving about 16,000 acres, or 200 farm units, not yet taken up. The rate of filing has been about 100 farm units a year. The Government farm unit is 40 to 80 acres, dependent on location.

10. The soil is gravelly and sandy loam, and is generally shallow. In the low, flat parts drainage is necessary. Results from the farms cultivated in the Government project, and also under a private ditch in the vicinity of Cody on the south side of the river, indicate that good crops can be raised. The main crops are oats, wheat, potatoes, alfalfa, etc., with a tendency toward the greater cultivation of alfalfa. Good prices have been obtained, and the settlers appear well satisfied with conditions this year. These crops are not of a nature to warrant a high construction or operating cost. Dry farming is not successful. The rainfall on the irrigable area is from 6 to 10 inches. There are several Government town sites on the project. Powell is the principal town at the present time.

11. In addition to the irrigable lands in the valley of the Shoshone River, there lies some five or six miles to the south of the valley a large area of good land known as the Oregon Basin, which can be irrigated from the Shoshone and which has water rights on the South Fork of that river. It is estimated to comprise about 125,000 acres of irrigable land held under the Carey Act. Some work has been done in ditch construction by private parties, but the water supply has never been sufficient or satisfactory, no water having as yet been obtained from the South Fork. Water can be brought by tunnel from the Shoshone Reservoir. To do this work economically the height of the Shoshone Dam should be increased. It has been suggested that there be obtained from Congress the necessary authority to sell water to irrigate this basin, if detailed surveys show this plan to be feasible. This will reduce the cost of construction and operation in the Shoshone Valley project.

12. *Engineering structures.*—The constructions on the Shoshone project are well designed and built, and of a permanent nature. For the high dam special study by an expert engineer employed for the purpose was made of the temperature and other strains, and based on his conclusions its design was made by a board composed of engineers of the Reclamation Service and consulting engineers. All the usual precautions seem to have been taken to secure a stable and enduring structure both in design and construction.

13. *Cost.*—The total amount allotted to December 30, 1910, is $3,828,000. The estimated cost of completion, as submitted to the board by the Reclamation Service, is $3,411,000, making a total cost for the project of $7,239,000. The estimate of completion is divided as follows:

Garland-Frannie unit	$650,000
Willwood unit	1,000,000
High-line unit	1,500,000
Contingencies, maintenance, etc	261,000
Total	3,411,000

14. The Garland-Frannie unit estimate, including simply extensions of ditches and laterals, may be taken as reasonably accurate. Test pits have been dug along the high-line canal but the structures necessary to bring water out of the canyon and the structures for the Willwood unit have not been designed, and these estimates must be considered approximate. The chief engineer of the Reclamation Service has submitted a revised estimate of completion of $4,000,000. In view of certain changes in the plan so as to include more land within the project, it seems safe to adopt this increase, making the total estimated cost of the project $7,828,000.

15. On this assumption and of a land area of 132,000 acres under the project, the cost per acre would be $59.23. If a total area of 164,000 acres can be irrigated, the cost would be $47.70. The announced cost of construction on farm lands already thrown open is $45 for 15,237 acres and $46 for 15,662 acres, a total amount of $1,406,117, leaving a remainder of $6,421,883 to be borne by new units. On the basis of a total of 132,000 acres of irrigable land in the whole project, this would bring the cost of construction of each remaining acre to $63.51. If the total amount of land is 164,000 acres it would be $48.20 per acre. It may prove possible to sell surplus water to private companies, if allowable under the law, thus reducing the cost per acre.

16. Having in view the nature of the soil and climate, and the kind of crops raised, a cost of construction of over $50 per acre it is thought would not lead to the rapid settling of this country. It would therefore be desirable to include as much land as possible in the project to reduce the cost per acre.

17. The cost of maintenance and operation has been $1 per acre. It is expected when more land is opened to reduce this to about 75 cents. This is thought to be reasonable and within what the land can bear. The present annual cost of maintenance and operation is not now returned because of the small number of units opened; and the deficit, it is understood, will be charged against new units. The estimated returns to December, 1910, are about $225,000.

18. The cost of construction is in excess of the first estimates, due to increase in price of material and labor, unforeseen difficulties, damage by floods, etc. The high dam, the necessary length of tunnels and supply canals make the cost per acre high.

19. *Comments.*—The completion of the Garland-Frannie unit will open from 42,101 to 55,700 additional acres. The estimated additional cost, including the proportion of maintenance and contingencies, is from $700,000 to $800,000. As this relatively small additional cost will bring a large area under irrigation, it is thought desirable to do the work necessary to open the complete unit as rapidly as land is taken up.

20. The construction of the high-line canal will irrigate, it is estimated, 36,500 acres to 40,000 acres, and the pumping unit an addi-

tional 7,500 acres. The estimated cost is $1,620,000 to $2,000,000. The land to be irrigated by the canal lies on the benches above the river, extending from the canyon down. It appears to be of the same general character as the remainder of the project. The irrigable land lies well and can be readily drained. There will be, however, considerable waste land. A reason for the early construction of this canal lies in the fact of its being largely part of the Cody-Salisbury tract turned over to the United States with a valuable water right. Part of the Cody-Salisbury tract is now irrigated under the Garland Canal, but much can be irrigated only by the high-line canal.

21. The Willwood Canal, when constructed, will irrigate 22,500 to 30,000 acres, at an estimated cost of $1,100,000 to $1,300,000. The estimates are still indefinite. The character of the soil is similar to other tracts and the land lies well for irrigation and drainage.

22. The estimates both of area of land irrigated and cost of construction under the high line and Willwood Canals are not sufficiently definite for satisfactory comparisons of cost per acre. It appears from the estimates of the Reclamation Service that the Willwood extension will be slightly more costly per acre than the land served by the high line. It lies somewhat better and has less waste land.

23. It is thought that the high-line canal should be constructed before the Willwood on account of the conditions under which a large part of the water rights were acquired by the United States, the better existing railroad facilities, the approximate equal cost per acre, and the fact that the seepage water from the upper unit that returns to the river can be used on the lower lands.

24. While the cost of the project per acre will be larger than at first estimated, and while, in order to recover the full amount, the cost reaches an amount per acre which, it is thought, will but slowly attract settlers, the board is of the opinion that the work should be completed. It is considered that this completion should be gradual, based on the rapidity with which the lands are taken up. That all of the lands will be ultimately entered appears probable.

25. *Summary.*—(1) The completion of the project is feasible from an engineering and an economic standpoint.

(2) The lands and water supply are all within the State of Wyoming.

(3 The water supply is sufficient for the whole project.

(4) The total amount of land is about 164,00 acres. One per cent of this is private land and 10 per cent State or school land. The remainder is subject to the reclamation act.

(5) Of the total estimated cost of $7,828,000, about one-half has been expended.

(6) The storage system for the whole amount of land is practically completed.

(7) Further expenditures will be used to extend the distribution system.

(8) Only about 35,000 acres can be irrigated without further extensions.

(9) The land can bear the cost of construction, estimated at about $50 per acre.

(10) The board believes the project to be worthy, and recommends that the completion of the Garland-Frannie Canal system be first

undertaken, followed by the high line and then the Willwood Canals, and that the rate of work should depend on the rapidity with which lands are taken up. As the cost will reach so closely what it is thought the land can stand for construction charges, and as the water supply is indicated as sufficient, the full amount of 164,000 acres should, if practicable, be brought into the project.

(11) The following allotment is recommended for the four years 1911–1914, inclusive:

From the fund	$2,000,000

APPENDIXES.

Appendix to Section V.

GRAND VALLEY PROJECT.

WATER SUPPLY.

[By the project engineer.]

1. The Central Colorado Power Co. contemplates the construction of storage reservoirs to maintain the flow through their power plant near Glenwood Springs at 1,250 second-feet. The dotted line on the hydrograph shows the estimated effect on the Palisade flow due to such use of stored water in 1902. This shows that 1,600 second-feet may be expected as a minimum when such storage is developed.

2. There is now pending in the Mesa County courts the first adjudication of the water rights of the irrigation ditches in this water district. No decrees have been entered and only a few of the ditches have as yet filed their statements of claim. No report is expected from the referee before March, 1911. From the records of the water filings and data concerning the flow in the various ditches, and the acreage irrigated, the following liberal estimate of the different priorities which will probably be decreed has been formulated.

3. The ditches are listed in the order in which their head gates are located along the river.

	Priority No.	Power water.	Irrigation water.
		Sec.-ft.	*Sec.-ft.*
Orchard Mesa irrigation district	7	325	125
Government high line	6	120	[1] 710
Mesa County irrigation district	4	377	[2] 31
Palisades irrigation district	4	500	[2] 90
East Palisades irrigation district	[3] 5	.....	10
Grand Valley Irrigation Co	1	.....	521
Rose Point filing	3	100	[4] 6
Orchard Mesa power	2	214	10
Totals	.....	1,636	1,453

[1] Fifty second-feet seepage returns to river above next head gate.
[2] Power water based on 40 per cent total efficiency of turbines and pumps.
[3] Doubtful.
[4] Abandoned to the United States.

4. The Orchard Mesa irrigation district power water is returned to the river at the Grand Valley head gates, and the high line power water will be returned a short distance below the East Palisades intake. No other power water is carried by the canal past any canal intake.

5. With priorities as above the supply of water lawfully available for the high line is estimated as follows for different conditions:

6. First, assuming that the United States depends on its own filings and acquires no additional priorities, then the high line would draw a full head until the flow in the river fell to 1,798 second-feet. As the river continued to

fall the head in the canal would decrease and be shut off entirely when the river flow was less than 1,018 second-feet.

7. This use of the river necessitates the wasting of 577 second-feet past the last canal intake when all canals are running full capacity.

8. Second, either of the two locations proposed for the high line can supply water by gravity to the canal of the Palisades irrigation district, and it is generally believed that the courts will allow the United States to condemn and use their power water for irrigation if the flow in their ditch is maintained. On this basis the high line would draw a full head until the river fell to 1,536 second-feet, and would be reduced to 90 second-feet when the river fell below 876 second-feet. It would be entitled to draw water for the Palisades district lands with the river running between 866 and 776 second-feet. Under this arrangement 1,788 second-feet would have to flow to supply all priorities and 341 feet would be wasted.

9. Third, if the United States acquired the power water of the Smith Bros.' Orchard Mesa power canal in addition to that of the Palisades district, the high line would draw its full head with the river carrying 1,322 second-feet and cease to draw except for the Palisades district and Smith Bros. when the supply fell below 662 second-feet; 301 feet of power water would be wasted past the Grand Valley head gate in this case.

10. Fourth, in case the Government acquired the Mesa County district's filing for power as well as those of the Palisades district and Smith Bros.', the high line would still draw water at the same times as noted in the third case, but no water would be wasted, and the Orchard Mesa district could get a full head when there was 301 feet less water in the river.

11. Some anxiety has been felt by the people interested in the Grand Valley that eastern slope users might get a valid right to the use of some of the Grand River waters which are required on the western slope during times of low flow. The four appropriations that have been filed to divert water from the Grand River to the eastern slope amount to 3,876 second-feet. One claimant has built capacity to divert 48 second-feet and is diverting 12. So far as known, the remaining three appropriators have done no work. Investigation of available data relating to the watershed and run-off from the drainage basins concerned would indicate that it is impossible for these claimants to divert in excess of 6 per cent of the low flow of the Grand River at Palisades. It is believed that the feasibility of the Grand Valley project will be recognized, and that the project will be completed and in operation, and an adequate water right perfected before the demand for land and water on the eastern slope will justify the cost of building the necessary diversion tunnels to carry water from the Grand River across the Continental Divide.

12. It is apparent that if the rights of the Palisades and Mesa County districts and of the Smith Bros. are turned over to the Government, that the available water supply will be adequate to fully supply all canals at all times except during July and August of exceptionally dry years. During those months less water is demanded by the crops than earlier in the season, and part of this demand is in normal years supplied by rainfall.

13. It is estimated that about 70,000 acres are under cultivation in the Grand River watershed above Palisades. As a rule further development of irrigable lands in this territory will necessitate the storing of water, and in consequence a probable increase in the low-water flow in the river.

DUTY OF WATER.

14. The duty of water used in estimating the project's requirements has been figured at 100 acres per second-foot at the lateral head gate, or (allowing 20 per cent seepage and evaporation) 80 acres per second-foot at the controlling works above Palisades.

15. Records of the daily flow in the Grand Valley, Price, and Stub ditches have been kept by the Reclamation Service for the last two years. At no time has the duty been less than 80 acres per second-foot.

Appendix to Section VI.

UNCOMPAHGRE PROJECT.

WATER SUPPLY.

1. The water supply for this project is obtained from the Uncompahgre and Gunnison rivers, part of the flow of the latter being diverted through a tunnel of 1,300 second-feet capacity.

2. Discharge measurements of the Uncompahgre at the southern boundary of the project during the irrigating season are available for the period July, 1895, to September, 1899, and show a flow varying from 3,375 second-feet in May, 1896, to a minimum of 4 second-feet in September, 1899, with mean discharges, in second-feet, for the irrigating months as follows: April, 330; May, 670; June, 725; July, 360; August, 140; September, 103; October, 109.

3. Similar measurements for the period 1903–1910 are also available, and show a maximum flow of 1,870 second-feet in July, 1907, and a minimum of 67 second-feet in April, 1904, with mean discharges, in second-feet, for the irrigating months as follows: April, 250; May, 500; June, 890; July, 516; August, 340; September, 206; October, 155.

4. For 1902 one reading only is available, and this shows a flow of 63 second-feet on July 17, which probably decreased to nothing during August.

5. Discharge measurements of the Gunnison River were made at Iola, Colo., 1900 to 1903, at Whitewater, 1902, at Cimarron and Cory, 1903–1905, and at the river portal of the Gunnison Tunnel, 1905–1910.

6. Iola is above the river portal and above two important tributaries, the Lake Fork and the Cimarron River. Cimarron is at the junction of the Gunnison and Cimarron rivers, below any considerable tributaries and above the tunnel entrance.

7. Whitewater is over 100 miles below the intake of the tunnel, and Cory is 30 odd miles below the tunnel intake.

8. During the period 1905–1910 the flow varied from a maximum of 14,660 second-feet in June, 1905, to a minimum of 470 second-feet in September of the same year, with mean discharges, in second-feet, for the irrigating months, as follows: April, 2,174; May, 5,145; June, 7,704; July, 3,107; August, 1,562; September, 940; October, 917.

9. There are numerous appropriations of the waters of these rivers that antedate those of the Reclamation Service. On the upper Gunnison, above the tunnel portal, they aggregate 1,815 second-feet. It is not known whether this amount is being beneficially used, but owing to high altitudes (7,400 feet to 8,000 feet), which largely limit the crops to wild and timothy hay and to restricted irrigable areas, no increased use of water above the tunnel is probable even though authorized by decreed priorities.

10. On the Gunnison below the tunnel the prior appropriations aggregate 1,835 second-feet. Part of this amount will be supplied by return waters from the project and the remainder, about 100 second-feet, will have to be passed by the tunnel entrance, unless it can be supplied from tributaries entering below this point.

11. On the Uncompahgre, the appropriations below the point at which discharge measurements were taken aggregate 1,589 second-feet, but it is the expectation that before completion of the project all of these filings, together with the lands to which they pertain, will be absorbed and become a part of the project.

DUTY OF WATER.

12. The average rainfall at Montrose is about 9 inches, and the project is based upon supplying from the ditches 3 acre-feet of water per acre, which, with a seepage and evaporation loss in the distribution systems of 30 per cent, corresponds to a diversion duty of 4.2 acre-feet per acre.

13. The assumed, in acre-feet, demand for water measured at points of diversion and based on an irrigable area of 140,000 acres, is as follows: April, 83,000; May, 105,000; June, 106,000; July, 107,000; August, 88,000; September, 57,000; October, 41,000.

14. Such a demand requires a minimum flow of nearly 1,800 second-feet, and can only be supplied when the tunnel is running full and when the flow in the Uncompahgre aggregates 500 second-feet.

15. As the July flow of the Uncompahgre frequently falls below 500 second-feet, it will be necessary at such times to reduce the deliveries below that assumed. This, however, will not occasion a serious shortage, as, in the opinion of the board, a duty of 2.5 acre-feet per acre at the farm will fulfill all reasonable requirements.

16. By plotting the combined supply curves of the two rivers against the assumed demand curve, it is found that during the period 1903–1910, the following shortage would have occurred:

Years.	If all water is available for diversion.	If 100 second-feet are passed to satisfy priorities.
1903	32,000	41,000
1904	18,000	24,000
1905	18,000	35,000
1908	10,000	16,000
1910[1]	7,000	16,000

[1] To September 1, 1910.

17. These shortages are not serious, and if they represented the worst conditions it is questionable whether the expense of providing storage to overcome them would be warranted.

18. It appears, however, that in 1902 the flow of both the Gunnison and the Uncompahgre Rivers was much less than in any year since. Unfortunately, complete hydrographic data for 1902 are not available, but based upon the measured run-off of the Gunnison at Whitewater, 100 miles below the tunnel intake, storage to the extent of 125,000 acre-feet would have been required to maintain a constant flow of 1,300 second-feet up to September 25, and considerably more would have been required to maintain such a flow at the tunnel.

19. Present plans contemplate the storage of 105,000 acre-feet in a reservoir to be built at Taylor Park, in the headwaters of the Gunnison. This storage will provide a full supply for all but years of abnormally low run-off, such as 1902, and a reasonable supply for even very low years.

20. No suitable storage reservoirs have been found on the Uncompahgre.

Appendix No. 1 to Section VII.

MINIDAKO PROJECT.

1. *Minidoka Diverting and Reservoir Dam.*—The dam, which occupies the main channel of the Snake River, is rock and earth fill, with concrete cut-off wall of varying height extending from abutment to abutment. The crest of the dam is straight in plan, with a maximum height as modified of 86 feet above the foundation and a length of 650 feet. The rock fill forming the lower or downstream portion of the dam is 10 feet wide on top, with upstream side slopes of 1 on 1 and downstream side slopes of 1½ to 1. The earth fill forming the upstream portion of the dam is 10 feet wide on top, giving a total width of the crest of 20 feet, the side slope of the reservoir side being 3 on 1. The foundation is solid rock, and all loose bowlders, etc., were removed. This dam is in process of completion and so far has shown but little leakage, which apparently comes through a seam in the foundation rock.

2. The left abutment of the dam, of concrete, forms the beginning of the concrete spillway, and the right abutment forms the left end of the regulating works, 180 feet in length. These regulating works consist of five sluiceways, each controlled by 8 by 12 feet sliding gates, the sills being 48 feet below the spillway crest, the sluiceways being excavated in the rock. Above the sluiceways in this section are the penstock openings for the power development. To the right of the regulating works are the headworks of the main canal for the north side unit, while the head gates and regulating works for the south side main canal are at the left end of the spillway. They are both controlled

by sliding cast-iron gates of the usual pattern. There are 9 gates on the north side, each 5 by 7 feet, with sills 9.5 feet below spillway crest. On the south side there are 12 gate openings, each 5 by 6 feet, with sills 6 feet below the original elevation of the spillway crest.

3. The spillway, lying between the main dam and the headworks of the south-side canal, is 2,400 feet in total development. It consisted originally of a concrete wier varying in height from 0 to 14 feet, following the high part of the rock bottom of the river, and was designed to pass 50,000 second-feet, with a maximum depth of water of 5 feet, over it. Owing to the fact that the main storage of this project is to be at Jackson Lake, some 275 miles by river above this dam, and to the fact that a large portion of the storage water released from the storage dam at Jackson Lake might be diverted by private users between the two points if their canals were staked too early in the season, it became desirable to divide the storage between the two points, thus enabling the river between the two points to obtain its natural flow and the private canals to be staked at low state of river before it becomes necessary to draw water from the upper reservoir. To accomplish this the diverting dam was converted into a storage dam of about 52,000 acre-feet capacity by raising the main dam, and by constructing on the crest of the spillway piers 2 feet thick, 8 feet high, 7 feet from center to center, their tops being connected by a bridge, and having arrangements by which flashboards may be placed on the crest, enabling the water surface to be raised 5 feet. The cost of this work was $29,000. When the additional head of water was brought upon the main dam, the material of which had been hydraulicked into place, additional material and height had to be added to the dam. This work was in progress at the time of the board's inspection, and its estimated cost is $22,000. On the south side, the relatively low ground of the bank at the shore end of the regulating works was raised by an embankment about 1,000 feet long, having a maximum height of 16 feet. It is 20 feet wide on top, and constructed of earth and rock fill in the same manner as the main dam. Both the dam and this embankment have a riprap protection on water slope where exposed to wave action.

4. The plan for this project now contemplates pumping by electricity to three different levels to supply high lands, the water to be supplied by the main south side canal, the pumping plants to be located near its extremity. The power for the pumping plants is to be supplied by a generating station at the Minidoka dam. This power plant has been constructed in part and will be completed during the ensuing year. It consists essentially of the following:

5. A hydro-electric power development having a capacity of 10,000 horsepower; 31 miles of 33,000-volt, three-phase transmission line, and 3 pumping stations, where the power is used in raising water for the irrigation of approximately 50,000 acres of land. Power for general purposes will also be supplied to the towns on the project some time before November 1, 1910.

6. *Power house.*—The power house is of reenforced concrete, 150 feet long and 50 feet wide, and is built against the downstream side of the concrete structure or dam containing the regulating works across the diversion channel. Extension to nearly double the present capacity of the plant can be easily made.

7. The buttresses of this concrete dam are built on 18-foot centers, forming bays, in each of which is a 10-foot penstock opening. Five of these bays will be utilized for the installation of the five 2,000 horsepower units of the present equipment; another bay contains the two exciter units; and the remaining bays included in the power house will be required in case of future extension.

8. *Main units.*—Each of the main units consists of a 2,000 horsepower vertical turbine, direct connected to a 1,490 kilovolt-ampere, three-phase alternator. The turbines are placed on the lowest floor of the power house, the center lines of the runners being 16 feet above mean tail water surface.

9. The generators are located on the main or generator floor of the plant. They generate three-phase current at 2,300 volts, 60 cycles, and have a rated capacity of 1,490 kilovolt-amperes.

10. *Exciters.*—Two 120 kilowatt exciters direct connected to 180 horsepower turbines furnish 125-volt exciting current for the main generators. Each exciter has its individual governor system, but all of the governors of the main units get their oil pressure from a central oil system, which is provided with a duplicate outfit of motor-driven gear oil pumps and pressure tanks.

11. *Transformers.*—Each generator is provided with a 1,490 kilovolt-ampere, 2,300 to 33,000 volt, three-phase air-blast transformer, connected to the generator

terminals by disconnecting switches so that each generator and its transformer form a unit delivering 33,000-volt, three-phase current to the high-tension bus.

12. *Switchboard.*—The plant is controlled from a switchboard located on an extension of the transformer gallery across the north end of the plant. This switchboard contains a panel for each generating unit and line and one panel for the two exciters. The highest voltage brought to this board is that of the exciters, which is 110.

13. *Transmission line.*—The present transmission line consists of a single circuit of copper wire run on wooden poles spaced approximately 150 feet apart. The line runs southwest from the dam, following the general direction of the main north side gravity canal and the Minidoka & Southwestern Railroad, to the Heyburn substation, a distance of 19 miles. From a point 10 miles from the dam a branch runs due south to pumping station No. 1, crossing the Snake River by a span 150 feet in length supported by steel towers. The poles on this part of the line are spaced 250 feet apart. The second transmission line will be built early in 1911. This line will cross the river near the dam and run directly to the pumping stations.

14. *Pumping stations.*—At the lower end of the south side gravity canal, is located the first pumping plant, having under the present plan a capacity of 500 second-feet. A portion of this 500 second-feet is diverted for use in the "G" canal, which supplies an area of 10,982 acres, while the remainder is elevated a second time at station No. 2. This station has a capacity of 375 second-feet. A portion of this water is diverted for use under the "H" canal, irrigating 15,922 acres, while the remainder is again lifted at a pumping station No. 3. This plant has a capacity of 200 second-feet and delivers water to the "J" canal, which supplies 23,414 acres of land. The lift at each station is 30 feet.

15. The three pumping plants follow very closely the same general design so that a description of one will suffice for all three. All of the buildings are of reenforced concrete with reenforced concrete roofs.

16. *Station No. 1.*—Pumping station No. 1 has a total length of 121 feet, the pump end of the building being 18 by 71 feet, and the part which covers the electrical apparatus being 30 by 50 feet in plan. The pump end will contain four 125 second-feet, double-suction, vertical, centrifugal pumps, each one of which is mounted in a separate compartment or pit at such an elevation that the top suction is normally submerged. Each pump is direct connected to a 600-horsepower vertical, 3-phase, 2,200-volt, synchronous motor operating at 300 revolutions per minute. In each station space is provided for one additional pump of 75 second-foot capacity, this space to be utilized should such additional capacity prove desirable or necessary.

17. Current is supplied to the motors by air-blast transformers, one 590 kilovolt-ampere transformer being provided for each pump. These transformers receive current at 30,000 volts from the high-tension bus, and deliver it to the low-tension bus at 2,200 volts. The wiring is so arranged that any one or all the transformers may be used with any motor. Two induction motor-driven exciters, either of which is of sufficient capacity to excite all of the motors, are conveniently located close to the switchboard. The switchboard contains one panel for each motor and one for the two exciters, besides panels for the auxiliary apparatus.

18. *Commercial-power substations.*—Provision has been made for supplying power to distributing companies in Rupert, Heyburn, and Burley. A transformer station at Rupert will supply that town, and one on the Snake River near Heyburn will supply both Heyburn and Burley. These two substations are identical in design and are of reenforced concrete structure, approximately 20 by 30 feet in plan. The stations are designed to receive power at 30,000 volts and deliver it to local distributing circuits at 2,200 volts. Each station contains three 75-kilowatt, oil-cooled transformers protected by expulsion fuses. A switchboard panel controls the circuit for each town, and lightning arresters are provided for both high and low tension circuits.

Appendix No. 2 to Section VII.

MINIDOKA PROJECT.

1. *Water supply.*—The water supply for the project is taken from the Snake River, having a watershed area above the diversion dam of about 22,600 square miles. The average elevation of the water shed is about 6,000 feet above sea level, and the estimated average rainfall is about 21 inches.

2. The duty of water for the project is estimated at 3 acre-feet per acre measured on the land.

3. The mean annual run-off of the Snake River at the Minidoka Dam is about 6,000,000 acre-feet, the maximum being about 7,500,000, and the minimum about 3,800,000.

4. Below is given a table showing the mean discharge in second-feet of the Snake River at the Minidoka Dam during the irrigation season for several years prior to the time when stored water was turned down the river:

Mean discharge, in second-feet, Snake River, below American Falls.

Year.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1896	5,241	9,357	39,551	13,341	5,450	4,972	4,975
1897	7,678	32,863	30,399	10,740	5,223	4,982	.....
1898	8,629	17,658	20,936	9,142	4,498	4,383	4,818
1899	6,028	12,187	29,142	26,270	8,477	5,813	5,598
1901	.....	23,020	15,700	4,511	2,115	2,568	4,600
1902	5,800	10,300	18,200	10,400	3,300	3,900	5,550
1903	7,023	10,170	19,813	9,674	3,228	3,897	5,553
1904	7,790	24,520	28,200	12,970	4,881	5,576	5,778
1905	5,780	8,925	10,910	4,545	1,976	1,955	3,415
1906	7,000	14,400	21,300	9,000	3,000	3,700	5,300
1907	.....	21,800	29,300	22,500	7,600	6,200	7,100

Total run-off in acre-feet.

Mean for eight years	5,900,000
Maximum	7,300,000
Minimum	3,800,000

5. Of these amounts the South Side Twin Falls project is entitled to 30/34 up to 3,000 second-feet, and the North Side Twin Falls project to 4/34 up to 400 second-feet, after which the Minidoka project is entitled to 1,726 second-feet under State engineer's permit dated January 6, 1909 (date of priority, Mar. 26, 1903). Other filings made for the Minidoka project on which no proof has yet been made are as follows:

August 6, 1908, 3,000 second-feet for irrigation and domestic use; January 30, 1909, 2,500 second-feet for power; March 10, 1910, 75,000 acre-feet for storage; March 10, 1910, 400,000 acre-feet for storage, all in Idaho, and on August 23, 1906, 300,000 acre-feet for storage in Wyoming, at Jackson Lake.

6. The natural flow of the river is not sufficient to supply the needs of the project for the entire irrigation season during the low years, and this deficiency is supplied by storage at Lake Walcott and at Jackson Lake. At Lake Walcott storage works for 52,000 acre-feet are now constructed. This reservoir, located just above the diversion dam, also serves as an equalizing basin for the control of the water turned down from Jackson Lake. At Jackson Lake a temporary dam has been in use to store the necessary water for the last three years. Permanent works for the storage of 380,000 acre-feet are now being built at that point.

7. The low-water flow of the Snake River up to 3,400 second-feet must pass over the Minidoka Dam to supply the rights of the Twin Falls projects, which are located farther down the river. This amply protects the power filings for the Minidoka project for all time.

8. In determining the storage required the following assumptions were made by the Reclamation Service and the result computed in the manner indicated:

(1) That the minimum flow in the Snake River occurred in 1905.

(2) That at any time during the delivery of stored water the natural flow of the river can not be lawfully determined within 500 second-feet.

(3) That 25 per cent of the stored water will cover the loss due to seepage, evaporation, and misappropriation of water by the Idaho Falls irrigation district.

(NOTE.—This assumption is based upon actual measurements taken during summer of 1909.)

(4) That 132,000 acres of land are to be irrigated by the Government.

(5) That 1 second-foot per 80 acres of land must be delivered at the head gates of the Minidoka project (a total of 1,650 second-feet).

(6) That the South Side Twin Falls Co. have prior rights up to 3,000 second-feet of natural river flow and that the North Side Twin Falls Co. have prior rights up to 400 second-feet of natural river flow.

(7) That the reservoir at Lake Walcott will store 52,000 acre-feet of the total storage required by the project.

(8) That 700 second-feet of water is returned to the river flow by seepage from the Minidoka project, according to measurements made in 1909.

(9) That, though the legal irrigation season in Idaho extends from April 1 to November 1, no stored water will be needed after October 10.

9. *Methods of computing.*—The following lines were placed on the "Hydrograph" of the Snake River at Montgomerys Ferry, which is located about 6 miles below Minidoka diversion and storage dam:

(1) A line representing the minimum flow at the Milner Dam—that is, 700 second-feet greater than the minimum flow at Montgomerys Ferry—and extending over the time that the river flow is less than 3,400 second-feet. Milner Dam is the diversion dam of the South Side Twin Falls project (private), and is located about 5 miles below the lower limits of the project.

(2) The 3,400 second-foot line which represents the lawfully natural river flow due the Twin Falls companies.

(3) The 2,900 second-foot line covering errors in stream measurements under second assumption (3,400—500=2,900).

(4) The 5,050 second-foot line which represents the flow required in the river to supply the necessary 1,650 second-feet of water for the Minidoka project and the 3,400 second-feet for the Twin Falls projects.

10. The 5050 line shows that stored water must be delivered to the Minidoka project from July 11 to October 10, making 91 days. This shows a total of 353,600 acre-feet, 52,000 acre-feet in Lake Walcott. Therefore, 301,600 plus 25 per cent represents storage required in Jackson Lake Reservoir and equals 376,000 acre-feet, say, 380,000.

11. It will be noted—

(1) That the assumed acreage exceeds that in the project by 7,500;

(2) That the diversion of 1,650 second-feet for 193 days, April 1 to October 10, means the diversion of 636,900 acre-feet, or sufficient to provide 3 acre-feet per acre for 132,000 acres after deducting 37½ per cent for seepage and evaporation losses in the distribution system; and

(3) That provision is made for a loss of 500 second-feet during the delivery of stored water in addition to a 25 per cent loss for seepage, evaporation, and misappropriation.

12. In the opinion of the board these assumptions are very liberal. In most projects no effort is made to fully provide for the year of lowest measured run-off, but rather for a mean of the years of low run-off on the assumption that a slight shortage in supply at infrequent intervals would be less objectionable than the cost of providing storage for years of extreme low run-off.

13. While the storage provided on this project seems somewhat larger than necessary, it will probably prove to be a good investment if the project is extended or if congressional authority is eventually obtained for the sale of surplus water.

14. Attention is invited to the fact that storage filing in Wyoming is for 300,000 acre-feet, while the capacity of Jackson Lake Dam is 380,000 acre-feet. It is suggested that an additional filing for 80,000 acre-feet be made.

Appendix No. 1 to Section VIII.

BOISE PROJECT.

1. *Deer Flat Reservoir embankments, upper and lower.*—These embankments were visited by a committee of the board on September 9, 1910. By their construction a natural depression in the surface is converted into a reservoir with a total capacity of 186,000 acre-feet and an available capacity of 170,000 acre-feet. These embankments are both earth fill, the upper containing 932,200 cubic yards and the lower 936,600 cubic yards. The earth-fill type was adopted because no other suitable material was available and the foundations were not suitable for masonry construction.

2. The general dimensions are as follows:

	Upper embankment.	Lower embankment.
Height.....feet..	70	40
Length of crest.....do....	4,000	7,200
Width of crest.....do....	20	20
Side slopes:		
Reservoir side	3:1	3:1
Outer slope	2:1	1½:1

3. The subsoil in the upper embankment is composed of about 4 feet of ordinary soil, then 3 or 4 feet of hardpan, after which sand and gravel were found to an indefinite depth.

4. At the site of the lower embankment the soil is about 6 feet in depth with a somewhat thicker layer of hardpan, followed by sand and gravel. In each case a cut-off trench was constructed and filled with puddled earth, the remaining original surface being plowed in order to make good bond with the fill. The only arrangement for draining the reservoir is through the headworks of the canals forming the distribution system. These dams are both straight in plan; and the puddled ditch was carried up into the end slopes forming the abutments. There is no spillway, as it is proposed to control the water entering the reservoir through the main supply canal. This reservoir is filled by the main supply canal, called the "New York Canal," leading from the diversion dam in the Boise River to where it discharges into Indian Creek. After following Indian Creek about 9 miles the water is again diverted into a supply canal leading to the reservoir. The inlet works at the reservoir end of this supply canal is a concrete structure of the usual form, controlled by sliding gates, riprap protection being placed around the discharge to prevent scour. The outlet works to the distributing canals are located in both embankments. The upper dam has two sets of outlet gates, one set near each end. In one of these sets, a conduit is placed under the embankment and has the usual gate tower at the inner end. The capacity of the sliding cast-iron gates, of which there are four, is 650 second-feet. The outlet at the other end of the upper embankment is a simple conduit running under the embankment, controlled by a gate at the lower end, approximately 6 by 8 feet, with a capacity of 80 second-feet. In the lower embankment the discharge conduit lies under the embankment and is of concrete with the usual tower, etc., in the reservoir. It is controlled by sliding cast-iron gates of the ordinary type, and the delivery is about 650 second-feet.

5. In both embankments the earth fill was placed in layers, dampened and rolled. It is the purpose to place on the reservoir side of each embankment riprap protection, at present lacking. There will be needed to complete the reservoir another small embankment, not yet constructed, for closing a low place in the rim of the reservoir.

6. The cost of the upper embankment was $302,777.51, and of the lower $288,590.09. In both cases this is exclusive of the general expense charges. In order to aid in irrigating lands during the season of 1910 water was diverted to the reservoir to a depth of 7 feet. As a result of this head no leakage was observed under the lower embankment, but leakage amounting to at least 1½ second-feet occurred under the upper embankment. To correct this leakage, which seemed to come through the subsoil, a blanket of gravel, 200 feet wide, 12 feet thick at the toe of the dam and 4 feet thick at the outer edge, was

placed below the embankment. At the outer edge of this blanket a row of sheet piling was driven 16 feet into the ground. Tile drains were then laid each way under this edge of the blanket to connect with the central drain, led out below. In addition tile drains were laid approximately at right angles to these collecting side drains, up to the drains previously laid under the toe of the dam. The total cost of this work was $21,025. While it appears that the leakage at the upper embankment comes through the subsoil beneath, it is believed that the leakage should be kept under constant observation. Experience with a small reservoir in the neighborhood, in which the bottom proved to be porous, indicates that large seepage losses may be expected in the reservoir and its usefulness correspondingly reduced.

Appendix No. 2 to Section VIII.

REPORT OF COMMITTEE THAT EXAMINED SITE FOR BOISE RIVER STORAGE RESERVOIR.

1. The committee visited both of the possible dam sites for the proposed Hell Gate Reservoir, i. e., at Hell Gate and at Arrow Rock. It appears from examination of data collected by the United States Reclamation Service that a masonry dam can be constructed at either site to store 150,000 acre-feet (the capacity proposed); but that the lower (Arrow Rock) site has some points of superiority. The estimated cost of dams at the two sites are practically the same, and each provides for storage of 150,000 acre-feet. The Hell Gate Dam would have a maximum height of 303 feet, raising water 212 feet, and the Arrow Rock Dam would have a maximum height of 318 feet, raising water 212 feet. The chief points of superiority of the Arrow Rock over the Hell Gate site are the better quality of the granite on which dam is to be founded; the lesser average thickness of overlying materials in bed of stream; the lesser extent of volcanic capping; the somewhat more accessible site and the slightly lesser cost.

2. The cost of storage on the Boise River will be high, but the examinations of the Reclamation Service indicate that it will be less for the Hell Gate Reservoir (with dam at Arrow Rock) than for any other site or sites on the river. Even this site requires a high masonry dam, which must be constructed of gravity section. On account of the depth of rock in the bed of the stream much difficulty may be expected in the construction of that portion of the dam below low-water level.

The following estimates are submitted by the United States Reclamation Service:

Rough estimate cost Hell Gate Dam.

One hundred and fifty thousand acre-feet; rubble masonry, type A; raising water 212 feet; dam, 303 feet high; crest elevation, 3,212; flooding, 1,920 acres; watershed area, 2,207 square miles.

Railroad, Barberton to Hell Gate, 20 miles, at $20,000		$400,000
Plant		200,000
Freight, exclusive of cement, sand, and gravel		25,000
Tunnel, 900 linear feet, at $80		72,000
Gates		100,000
Cofferdam		150,000
Excavation in cofferdam:		
20,000 cubic yards rock, at $3	$60,000	
186,000 cubic yards bowlders, gravel, and sand at $2	372,000	
		432,000
Excavation above water for dam:		
33,100 cubic yards rock, at $1.10	36,100	
27,000 cubic yards earth and loose rock, at 60 cents	16,200	
		52,300
Rubble masonry in dam, 412,200 cubic yards, at $6.25		2,576,300
Spillway		330,000
Incidentals, 10 per cent of above items		433,700
Engineering and administration		433,700
Total cost		5,205,000

Cost per acre-foot for 150,000 acre-feet, $34.70.

Rough estimate cost Arrow Rock Dam.

One hundred and fifty thousand acre-feet storage; rubble masonry dam, type A; raising water 212 feet; dam, 318 feet high; crest elevation, 3,180; flooding, 2,050 acres; watershed area, 2,207 square miles.

Railroad, Barberton to Arrow Rock, 17 miles, at $20,000		$340,000
Plant		200,000
Freight, exclusive of cement, sand, and gravel		25,000
Tunnel, 900 linear feet, at $80		72,000
Gates, $100,000; cofferdam, $150,000		250,000
Excavation in cofferdam:		
21,000 cubic yards solid rock, at $3	$63,000	
143,000 cubic yards gravel and bowlders, at $2	286,000	
		349,000
Excavation above water for dam foundation:		
52,000 cubic yards solid rock, at $1.10	57,000	
10,000 cubic yards earth and loose rock, at 60 cents	6,000	
		63,000
Rubble masonry in dam, 432,000 cubic yards, at $6.25		2,700,000
Spillway		300,000
Incidentals, 10 per cent of above items		430,000
Engineering and administration		430,000
Total cost		5,159,000

Cost per acre-foot for 150,000 acre-feet, $34.39.

Appendix to Section XI.

MILK RIVER PROJECT.

WATER SUPPLY.

1. The flow of the Milk River is not in itself sufficient for the irrigation of the areas included within this project, and recourse is had to St. Marys River which rises in the United States and flows north through Canada into Hudson Bay. The Milk River also rises in the United States and flows for about 200 miles of its length through Canadian territory before returning to the United States.

2. The diversion of part of the flow of St. Marys River into the Milk River has been under consideration for the last 20 years, but recently, since the execution of a treaty between the United States and Canada, has this diversion been equitably possible. The treaty, which was signed in 1909 and proclaimed May 13, 1910, provides that these two rivers, the St. Marys and Milk, shall be treated as one stream for the purposes of irrigation and power, and the waters thereof apportioned equally between the two countries. It is also provided that more than one-half may be taken from one river with a corresponding reduction in the amount used from the other river. A further condition provides that during the irrigation season, from April 1 to October 31, inclusive, the United States shall be entitled to prior appropriation of 500 cubic feet per second of the waters of the Milk River, or so much of such amount as constitutes three-fourths of its natural flow, and that Canada shall have a similar prior right to the flow of the St. Marys River.

3. Gaugings of the St. Marys River have been made annually since 1902. Most of them were made at Cardston, Alberta, just north of the International Line. Others were made at Kimball, Alberta, and near Babb, Mont., while still others were made near St. Marys, the site of the proposed storage dam. From these gaugings the average run-off of the St. Marys River is found to be approximately 740,000 acre-feet, varying from a maximum of 1,108,000 acre-feet to a minimum of 516,000 acre-feet. A study of the hydrographs made by the Reclamation Service also shows that it is possible by means of storage to satisfy Canada's prior right and still divert 850 second-feet during the irrigation season, April 1 to October 31, inclusive. The storage that would have been required to furnish such a supply during the period 1903 to 1909, inclusive, varies from a minimum

of 74,800 acre-feet to a maximum of 174,700 acre-feet. As storage to the amount of 218,000 acre-feet can be provided in St. Marys Lakes at reasonable cost a continuous diversion of 850 second-feet for 7 months, or a total of 360,000 acre-feet, is assured without trespassing upon Canada's prior rights.

4. Discharge measurements on Milk River have been made at Havre, Mont., 60 miles below the international boundary, since 1898, at Malta since 1902, and Hinsdale since 1908. The discharge as measured at Havre is much less uniform than that of the St. Mary River, showing an average discharge of 230,000 acre-feet, with a maximum of 750,000 acre-feet and a minimum of 30,000 acre-feet, with two successive years of low run-off, namely, 1905, 30,000, and 1906, 70,000.

5. Storage on the river is to be provided in Nelson Reservoir for 142,000 acre-feet.

6. Prior water rights in Milk River and its tributaries amount to approximately 500 second-feet, part of which will be merged with and become a part of the project, and the filings of the United States cover the remainder of the flow. Filings have also been made by the United States on all of the unappropriated waters of the creeks and coulees entering Milk River above the lowest diversion dam.

7. The average rainfall at Havre since 1881 has been 13.6 inches, with a minimum in 1905 of less than 7 inches. Nearly 50 per cent of the annual precipitation occurs in May, June, and July. This fact, together with past experience in this valley, leads to the conclusion that 1½ acre-feet per acre per annum on the land will be a sufficient allowance, if it can be delivered during the growing season.

8. To determine the amount of water that could have been delivered to the land during the period 1902–1910, had the system as now planned been completed, a comprehensive analysis of the data available has been made by the Reclamation Service. In making this analysis such portion of the daily flow of the Milk River at Havre as is secured by treaty to the United States, supplemented by the proposed diversion of St. Mary River water, has been compiled, together with the daily quantities that could have been diverted through the Chinook diversion canals. The capacity of these canals is assumed as 500 second-feet, the irrigable area under them being 100,000 acres.

9. To determine the daily amount available for diversion at Dodson Dam, the second diversion point, there was added to the daily quantities remaining after the Chinook diversion the daily accretions to the stream flow between Havre and Malta, the latter being for practical purposes coincident with the Dodson Dam. These daily accretions were determined by subtracting from the daily discharge at Malta the discharge at Havre of two days previous. It will be noted that these accretions are net accretions and exclude from consideration the amount that was being used for irrigation between Havre and Dodson Dam. The Dodson canals are to have a combined capacity of 1,100 second-feet, and the amount that could have been diverted daily through them from the available supply has been tabulated for each day of the nine-year period for which discharge measurements are available.

10. In a similar manner the daily quantities remaining in the river after the Dodson diversion were tabulated and to them added the daily accretions between Dodson Dam and Vandalia Dam, the latter being determined by subtracting from the discharge at Vandalia (Hinsdale) the discharge at Dodson Dam (Malta) of one day previous. From the daily quantities thus available at Vandalia Dam the daily amounts that could have been diverted through a canal of 200 second-feet capacity were determined.

11. In the following tabulated statement, prepared by the Reclamation Service, is presented a summary of the results that could have been obtained during the years 1902 to 1910, inclusive, for the Dodson and Nelson Reservoir divisions, after furnishing the canals in the Chinook division with 500 second-feet continuous flow. From this table it appears that for all the years in the period, including the extremely dry years—1905 and 1910—all lands in the project could have been furnished with 1½ acre-feet per acre per annum on the land, delivery being made through a period of seven months. In the estimates allowance is made for a 25 per cent seepage and evaporation loss in the canals, including the St. Mary diversion canal, and for an annual evaporation loss in Nelson Reservoir of 5 feet depth of water, equivalent to 20,000 acre-feet. No allowance is made for evaporation from that portion of Milk River used in conducting St. Mary water, as the additional supply will but slightly increase the water surface exposed to evaporation.

Supply available for Dodson and Nelson Reservoir divisions.

[Acre-feet.]

Years.	1	2	3	4	5	6	7	8
1902	271,945	149,945	129,945	.....	28,000	101,945	21,945	21,945
1903	321,237	199,237	179,237	13,199	14,801	164,436	84,436	106,381
1904	244,224	122,224	102,224	14,519	13,481	88,743	8,743	115,124
1905	105,472	43,472	23,472	.....	28,000	− 4,528	− 84,528	30,596
1906	231,710	109,710	89,710	14,175	13,825	75,885	− 4,115	26,481
1907	336,318	214,318	194,318	33,312	.....	194,318	114,318	140,799
1908	242,157	140,157	120,157	9,985	18,015	102,142	22,142	[2] 142,000
1909	317,024	195,024	175,024	46,778	.....	175,024	95,024	[2] 142,000
1910	172,623	50,623	30,623	10,783	17,217	13,406	− 66,594	75,406

[1] Accretions from drainage basin between Malta and Hinsdale not included for years 1902 to 1907, inclusive.
[2] Proposed maximum capacity of Nelson Reservoir.

(1) Amount which could have been diverted at Dodson Dam after the diversion of a continuous flow of 500 second-feet into canals in the Chinook division.

(2) Amount which could have been stored in Nelson Reservoir, 122,000 acre-feet having been used in the irrigation of the 61,000 acres in the Dodson division.

(3) Amount which could have been delivered from Nelson Reservoir, deducting 20,000 acre-feet for evaporation from the reservoir.

(4) Amount which could have been delivered into Vandalia Canal by direct diversion from Milk River after all diversions into canals above.

(5) Amounts which would have been required from Nelson Reservoir to have given the Vandalia Unit its full supply of 28,000 acre-feet.

(6) Balance remaining in Nelson Reservoir for Nelson Reservoir North and South Canals, and for storage for use in subsequent years.

(7) Amount which could have been carried over in Nelson Reservoir for use in subsequent years after giving to lands under Nelson Reservoir North and South.

(8) Amount stored in Nelson Reservoir at end of season.

12. In making these estimates the supervising engineer in his analysis states:

"All water supply where not shown by records has been disregarded. The flow has been considered from April 1 to October 31 only, whereas a considerable quantity of water may be obtained frequently during other months. In a number of instances records are lacking for parts of the period April 1 to October 31, and in such cases the flow has been disregarded for such times as records are not available. The return seepage, which will undoubtedly be considerable and will augment the supply for lower diversions, has been disregarded. The quantity of water assumed to be available from the flow of the upper Milk River has been limited to such part of the flow as is assured by treaty, whereas any surplus above this quantity at any time not required by Canada will enter the United States and be available for diversion. In determining the accretions to Milk River between Havre and Malta, the difference in discharges of the river at the two points has been taken. This disregards all diversions that were being made at that time between Havre and Malta and the full supply of 2 acre-feet per acre per annum was allotted the lands that were using this water for irrigation. In fact, in all instances an effort has been made to estimate not the probable supply, but the assured supply."

13. This analysis has been reviewed by the board, and with the following exceptions it concurs in the assumptions made and in the conclusions reached:

(1) It is believed that specific allowance should have been made for seepage and evaporation loss in the 26 miles of diversion canal between St. Mary and Milk River, in addition to allowing a 25 per cent loss from this source in the distribution system. If the loss in this main diversion canal is placed at 10 per cent, which is less than one-half of 1 per cent per mile, it would be equivalent to 36,000 acre-feet in a year.

(2) Attention is called to the disproportion in the assumed capacity of the Chinook Canals, 500 second-feet for 100,000 acres, and that of the Vandalia Canal, 200 second-feet for 14,000 acres. The necessary changes in the capacities would not, however, have unfavorably altered the result.

(3) It is questionable whether the delivery of 1½ acre-feet per acre at a more or less uniform rate during seven months of the year will meet irrigation

requirements in a region where the growing season is only five months. While the storage provided in Nelson Reservoir will serve in a measure to adjust the annual supply to the demand it must also serve to equalize the variable supply of different years. Whether it is large enough to fulfill both functions is a matter about which there is reasonable doubt.

14. As additional storage can if necessary be provided in Milk River, the above comments do not alter the conclusion that in normal years there will be a sufficient water supply for the 215,000 acres under the project.

15. The only other point to be considered is whether the amount to which the United States is entitled from the Milk River flow added to the amount which it is proposed to divert from St. Mary River will exceed one-half of the total flow of these streams. One-half of the combined average annual discharge of these streams is 480,000 acre-feet.

	Acre-feet.
Proposed to be used by the United States, 215,000 acres, at 2 feet	430,0000
Evaporation loss, Nelson Reservoir	20,000
Total	450,000

16. Seepage from the main diversion canal is not included in the above, as it will all drain into the St. Mary Basin and be available for use in Canada. There will be added to the above, however, the amount to which the Belknap Indians are entitled under court decree—125 second-feet—and also part of the amount now being used by other prior appropriators on Milk River, as all of them will not, probably, come in under the project. Assuming 75,000 acre-feet as the amount necessary to satisfy prior rights, the total use of Milk River water in the United States will aggregate 525,000 second-feet.

17. A comparison of the discharge measurements at Havre, Malta, and Hinsdale shows an average annual accretion between Havre and Malta of 40,000 acre-feet, and between Malta and Hinsdale of 35,000 acre-feet, a total of 75,000 acre-feet, or sufficient to satisfy the prior rights above referred to. In other words, the proposed use of these two streams is about 30,000 acre-feet less than the amount to which the United States would be entitled under the treaty.

Appendix No. 1 to Section XII.

SUN RIVER PROJECT.

DAMS AND RESERVOIRS.

1. *Warm springs reservoir and dam.*—The Reclamation Service has furnished the following description of this dam with proposed methods of construction:

"This is located on the North Fork of the North Fork of Sun River some 12 miles within the mountains, about a mile above the confluence of the North and South Forks. At this point the dam was planned to be constructed of loose rock fill, backed by earth placed by hydraulic process. About three-quarters of a mile below the dam site is a large talus of diorite, composed of rock from 1 to 30 or more cubic yards in size, and a good portion will be from 1 to 6 cubic yards. This material can be cheaply transported by gravity tramway to the dam site and placed therein by cableway. Test pits were dug from 1 to 25 feet deep upon the hill sides above the dam site, and ample supply of materials for making hydraulic fill was developed within 2,000 feet of this point of use. These consist of clay, coarse and fine gravel, and some bowlders. By placing the material in this manner it can be sorted by the water so that the interstices between the stones of the rock fill will be filled with impervious material, making that portion solid and water tight, as well as the backing. Also the sorting can further be carried out to place the coarser material upon the upstream face so that a paving will not have to be resorted to other than the selection of stones during construction to act as baffle rock to hold the hydraulic material in place. Water can be delivered for this purpose by building a ditch of some 20 second-feet capacity about 4 miles long from Bear Creek. Almost any desired head can be secured to give pressure at the nozzle. If the supply of Bear Creek should not prove sufficient for sluicing purposes as well as disintegration purposes, ample supply can be secured from South

Fork by a ditch about 7 miles long, which will catch the flow of Elk, Goat, and Bear Creeks en route. This could afterwards be used to supply an additional amount of water back of the dam if needed. The economical height of the dam is controlled by the occurrence of bed rock in the spillway, which is about 2,000 feet from the dam and behind the butte several hundred feet high. The crest of the dam was made 10 feet higher than for the spillway, so that it need not be overtopped, but floods will pass around the butte into the river. Top of dam was placed at contour 4,980 and flood line at 4,970, which will make a dam 190 feet above stream bed with a capacity of 156,868 acre-feet. At the dam site the foundation is of hard diorite where North Fork has cut through Sheep Reef. Bed rock shows across the river, and diamond drill borings have been made at three points to develop its continuity. The greatest depth of bed rock below stream bed is 25 feet, which gives a total height of dam from stream bed to crest of 215 feet.

"The outlet work will consist of a tunnel approximately 900 feet long, 10 feet in size, with a slight arch, passing through the left abutment, being in the solid diorite. The outlet gates will be controlled through a shaft rising from this tunnel which would be through solid rock, but more economic construction would probably necessitate the upper portion of the shaft to be of concrete in order to shorten the length of tunnel. A tunnel of this size with a slope of 0.01 will discharge 2,200 second-feet. When construction is begun on this feature, it will be necessary to construct the tunnel, shaft, and set the gates the first season in order to take care of the spring floods and provide a by-pass around the dam. The first season the dam will be built some 80 feet above stream bed in order to amply discharge the maximum flood, which probably does not exceed 4,000 second-feet.

"The completion of the Great Northern Railway to Augusta will materially assist in this work, and if the line is completed through the mountains it will run within a mile of the dam site."

2. While the board believes the cross section of a rock-fill dam here of the unusual height, 215 feet from the lowest point of prepared river bed, is feasible and practicable, it believes that should the railway be completed to the point near the site as suggested in the preceding paragraph it may be found that with the transportation facilities thus afforded the cost of a masonry dam will be but relatively little greater, and therefore that careful comparative studies and estimates of the two types should be made before the adoption of either type. As it will be several years before this structure is commenced, time is available. The estimate of cost of the Warm Springs Reservoir is as follows:

Dam:		
Rock fill, 380,000 cubic yards, at 75 cents	$285,000	
Earth fill, 1,031,000 cubic yards, at 5 cents	51,550	
Riprap, 38,500 square yards, 18 inches deep, at $1.25	48,150	
Outlet tunnel, 900 by 10 by 10 feet, at $80 per linear foot	72,000	
Gates, shaft, and gate house	50,000	
		$506,700
Gate tender's house and barn		2,000
Telephone line to canyon, 10 miles, at $200		2,000
Canyon road, 10 miles, at $2,000		20,000
Highway Bridge at Forks, 63-foot span		1,500
Bear Creek hydraulic-pressure ditch		2,000
South Fork hydraulic-supply ditch		43,300
Engineering and contingencies, 15 per cent		86,600
		664,100

3. If the slope of the rock fill is increased as proposed to one and one-half to one, instead of one to one, the amount of rock will be increased about one-third, necessitating an increase of estimated cost for work of $95,000, making the cost of dam $601,700, and the total cost of reservoir $759,000.

4. *Willow Creek Dam and Reservoir.*—This reservoir will when completed to full height serve two purposes:

(1) To store the flood waters of Willow Creek to supplement the flow of Sun River available for Fort Shaw Unit in dry years; and

(2) To store flood waters of Sun River by means of canal connecting it with the Sun River above the Canyon Diversion Dam.

5. For the first purpose the dam need be only 70 feet high, while to accomplish both ends the height is to be 110 feet. It is the present intention of the Recla-

mation Service to complete the dam for the first purpose only, leaving the additional height for the larger storage to be added later when required for new areas. This additional storage will be used by private users below the Fort Shaw Unit in exchange for which Sun River water can be diverted to the Pishkun Reservoir system and thus increase the irrigable acreage under it and which otherwise would not receive water.

6. The earth-fill type is the most suitable for the locality. The dam is designed to be 20 feet wide on top with side slopes of three on one on the reservoir side and two on one on the outer slope. The subsoil is compact glacial drift on top of sandstone and shale. The thickness of the material overlying this rock is 15 feet at the bottom of the creek and less on the hillsides. Four cut-off trenches are excavated to the underlying rock and filled with selected puddled material.

7. The reservoir slope is to be faced with a layer of selected glacial bowlders, 2 feet thick, hand placed. An outlet tunnel 584 feet in length passes around one end of the dam. It is circular in cross section, 4 feet 6 inches in diameter. Its capacity under 10-foot head is 400 second-feet. It is controlled by a sliding gate operated through a shaft, concrete lined, extending up to crest of dam.

8. The storage for Willow Creek is 16,700 acre-feet. The storage for the higher dam will be 84,000 acre-feet, the difference to be supplied from the North Fork of Sun River, as noted above.

9. The spillway for the lower dam is through a sag in the surrounding hills, which will, for the high dam, be closed by a small embankment. Another higher sag will form a spillway, if ever needed, for the higher dam. In each case the overflow discharges into a small creek about one mile away. The estimated cost of the dam, complete, is as follows:

Outlet tunnel and shaft to elevation 4,140 completed and gate set. Camp established, equipment and supplies assembled. Cut-off trenches practically done and embankment begun. Paving rock on hand for face to elevation, 4,140.

Dam:		
Earth fill, 460,000 cubic yards, at 28 cents	$128,800	
Supplying and placing 6,000 cubic yards paving, at $2.50	15,000	
Placing 4,000 cubic yards paving, at $1	15,000	
	4,000	
		$147,800
Dike, 210,000 cubic yards, at 35 cents		73,500
Raising gate-control shaft 40 feet, 100 cubic yards concrete, at $12		1,200
Gate house		500
Measuring weir in Willow Creek about 1 mile below dam, with diversion box for Floweree Canal to measure 400 second-feet (no design)		5,000
One mile, 200 second-feet canal, measuring weir to head Floweree Canal, 21,000 yards earth, at 18 cents		3,800
Engineering and contingencies, 15 per cent		34,800
		266,600

Appendix No 2 to Section XII.

SUN RIVER PROJECT.

WATER SUPPLY.

[Study of supervising engineer, H. N. Savage.]

The irrigation plan of the Sun River project contemplates the construction of a storage reservoir on the North Fork of Sun River controlled by the Warm Springs Dam, storing the flow of this branch of the Sun River; a diversion dam on the South Fork of the North Fork of Sun River diverting water into a supply canal discharging into the Warm Springs Reservoir; a diversion dam on the Sun River about 12 miles below the Warm Springs Reservoir diverting water into two canals, one on the north side of the river, serving as the supply canal to the Pishkun Reservoir, the other on the south side of the river, serving as a supply canal for the Willow Creek Reservoir; and the construction of the Pishkun and Willow Creek Reservoirs, with their subsidiary-canal systems. The water supplied to the Pishkun Reservoir will be taken out into a canal to

be constructed so as to cover the high lands to the north of Sun River. A portion of the water of this same reservoir is to be discharged into Deep Creek, a tributary of the Teton River, on which a diversion dam is to be constructed diverting water into a canal and irrigating lands on the southern slope of the Teton River basin. The water stored in Willow Creek Reservoir will be discharged into Sun River and will furnish partial supply for the Fort Shaw unit and for prior private water rights on Sun River below the mouth of Willow Creek, thus permitting a larger part of the low-water flow of the North Fork to be utilized in the irrigation of lands on the north side of the river.

A reservoir may be constructed at the site of Benton Lake, about 8 miles north of Great Falls, to which surplus water from the Teton Slope Canal may be conducted by means of a supply canal some 4 miles in length, and stored for the irrigation of some 21,000 acres lying on the north side of the Missouri River opposite Great Falls.

It is proposed to divert Bowl Creek, a tributary of Flathead River, into the head of Sun River. Bowl Creek, above the point of diversion, has a drainage area of about 9 square miles situated very near the continental divide.

The area of land to be furnished with water is limited by the available water supply and not by the area to which water can be delivered. The project could be increased to include double the irrigable area at present proposed, were a sufficient water supply available.

The flood stage of the Sun River occurs during the period when there will be large requirement for water for irrigation, the maximum flood usually occurring in June. Storage reservoirs are available for conserving the greater part of the winter flow and for regulating the summer discharge by the storage of the surplus waters during times of maximum floods.

The annual run-off of the Sun River ranges from 500,000 to 1,000,000 acre-feet, with an average of about 700,000 acre-feet. It is believed that this will be sufficient for the irrigation of from 300,000 to 350,000 acres. On this basis lands have been selected aggregating 322,000 acres, situated as shown in the following table:

	Acres.
Fort Shaw unit	16,000
North Side high-line unit	15,000
Greenfields unit	75,000
Teton Canal lands	195,000
Benton Lake unit	21,000
Total	322,000

STORAGE RESERVOIRS.

The areas and capacities of the principal storage reservoirs are given in the following table:

Reservoir.	Area.	Capacity.
	Acres.	*Acre-feet.*
Warm Springs	1,976	156,800
Willow Creek	2,285	84,320
Pishkun	1,542	45,747
Benton Lake	9,130	140,200

RECORDS OF RAINFALL AND RUN-OFF.

Records are available of the precipitation at Fort Shaw, Mont., from 1867 to 1886, inclusive, and from 1907 to date, also of that at Great Falls, Mont., from 1892 to date.

Records are available of the run-off of Sun River from 1906 to date, of the South Fork of Sun River from 1905 to date, of the North Fork of Sun River from 1905 to date. of Willow Creek from 1906 to date, and of Smith Creek, and of Ford Creek, tributaries of the South Fork, from 1906 to date.

Tabulated statements of precipitation, and hydrographs showing the flow of the several streams accompany the report on the Sun River project, submitted under date of August 10, 1910.

DUTY OF WATER.

A consideration of the records of precipitation and of its monthly distribution, as well as of the results of irrigation as practiced in the vicinity of the project, leads to the conclusion that 1½ acre-feet per acre per annum delivered on the land, will be an ample allowance. Losses from seepage in canals will be returned to a great extent to the river and will be available for diversions below, reducing to such extent the quantity to be turned down the river for supplying such diversions. It is believed that an allowance of 25 per cent will be sufficient to cover final losses from evaporation and seepage in canals, and that 2 acre-feet per acre per annum delivered at the head of canals will be ample to supply the total requirement. No allowance need be made for losses from evaporation from the river, the records of stream flow used to determine the available supply showing net supply after such losses have occurred.

PRIVATE WATER RIGHTS.

Appropriations of water prior to filings by the United States, stated in terms of the acreages to be irrigated and classified according to the various streams from which diversions are made, are given in the following tabulated statement:

Stream.	Irrigated.	Susceptible of irrigation.	Total.
	Acres.	*Acres.*	*Acres.*
North Fork of Sun River	1,522	21,360	22,882
Willow Creek and tributaries:			
Willow Creek and Little Willow Creek	1,691	725	2,416
Barr Creek	288	242	530
South Fork and tributaries:			
South Fork	4,659	3,471	8,130
Goss Creek	313	101	414
Blubber Creek	19	.....	19
Elk Creek	121	235	356
Dubray Creek	689	1,456	2,145
Ford Creek	194	.....	194
Smith Creek	207	478	685
Sun River below mouth of South Fork and its tributaries:			
Sun River	6,661	7,844	14,505
Dry Creek	424	415	839
Simms Creek	15	38	53
Total	16,803	36,365	53,168

In addition to the above, C. H. Campbell has a water filing of 468 second-feet on the waters of Sun River for power purposes, the power to be utilized in pumping water for the irrigation of his lands. The location of the power site is below all diversions by the United States and below practically all diversions by other appropriators. However, the appropriator is willing to relinquish this water right to the United States and receive in lieu thereof water right under the Government canal.

The adjudication of the Sun River water rights is now pending before the State court, and the tabulated statement of probable acreages is based upon defendant's answers and the referee's report.

In the following discussion, the quantities which will be used by private appropriators has been estimated on the basis of 2 acre-feet per acre per annum delivered at the head of canals, it being believed that any quantities in excess of these, if actually delivered to the land, will run off as surface drainage, or will be by seepage eventually returned to the river and will be available for diversion below.

AVAILABLE WATER SUPPLY.

The irrigation period may be assumed to extend from April 1 to October 31 of each year. The winter flow of the North Fork of the North Fork of Sun River will be stored in Warm Springs Reservoir. A diversion canal will be constructed of size sufficient to convey to this reservoir the flow of the South Fork of the North Fork, with the exception of the peak of floods. It is expected that ordinarily this canal can be operated during one-half of the winter period.

In the following discussion it has been assumed that the winter flow of the South Fork of the North Fork, except during the months of December and January, can be delivered into the Warm Springs Reservoir, and that that of the North Fork below the Warm Springs Reservoir during the same period can be diverted into the south or north supply canals and stored in Willow Creek or Pishkun Reservoir.

Stream measurements for the North Fork of Sun River have been made at a gaging station situated at a point about 9 miles below the proposed diversion dam for the north and south supply canals. In order that the quantities which may be stored in Warm Springs Reservoir may be estimated, it has been necessary to estimate what portions of the stream flow at the gaging station are derived from the North Fork of the North Fork, the South Fork of the North Fork and of the North Fork below the reservoir site. The areas of these drainage areas are approximately 208, 211, and 135 square miles respectively. The drainage area of the North Fork of the North Fork having a greater elevation, the relative quantities of run-off per square mile from the three areas are assumed to be in the proportion of 4, 3, and 3. On this basis the percentages of the total run-off for the three drainage areas are 45 per cent, 35 per cent, and twenty per cent, respectively.

Several appropriations of the waters of the North Fork have been made prior to filings by the United States. The total irrigable area covered by these prior appropriations is approximately 23,000 acres, of which approximately 1,500 acres have been irrigated. All of these filings are situated below the gaging station and the records of stream measurement show the stream flow before the diversion of any water for supplying the lands irrigated. Table 1 shows, for the years for which records are available, the estimated quantities of water which would have been available from the three drainage areas tributary to the North Fork and the balance available for use by the United States after deducting 46,000 acre-feet for supplying the prior rights for approximately 23,000 acres.

The total area of irrigable land for which appropriations of water have been made from the South Fork of Sun River prior to filings by the United States is approximately 11,950 acres, of which approximately 6,200 acres have been irrigated. All of these appropriations are above the South Fork gauging station, and records of stream measurement show the flow after the diversion of water for the lands irrigated. For supplying prior rights it is necessary, therefore, to deduct from the flow as shown by the gaugings only 11,500 acre-feet per annum for supplying the 5,750 acres of land not irrigated. Table 2 shows, for the years for which records are available, the estimated run-off of the South Fork of Sun River during the irrigation period and the amounts that would have been available for use by the United States after deducting 11,500 acre-feet for supplying prior rights.

The total area of irrigable land for which appropriations of water have been made from Willow Creek prior to filings by the United States is approximately 3,000 acres, of which approximately 2,000 acres have been irrigated. All of these appropriations are above the Willow Creek gauging station, and records of stream measurement show the flow after the diversion of water for the lands irrigated. For supplying prior rights it is necessary, therefore, to deduct from the flow as shown by the gaugings only 2,000 acre-feet per annum for supplying the 1,000 acres of land not irrigated. The remainder of the run-off for the entire year can be stored in Willow Creek Reservoir and sufficient additional water diverted from the North Fork and delivered through the North Supply Canal to fill the reservoir. Table 3 shows, for the years for which records are available, the estimated annual run-off of Willow Creek, the amounts which would have been available for storage and use by the United States after deducting 2,000 acre-feet for supplying prior rights and the amounts which it would have been necessary to divert from the North Fork to fill Willow Creek Reservoir to its full capacity of 84,300 acre-feet.

Appropriations of water from Sun River below the mouth of Willow Creek prior to filings by the United States embrace a total of approximately 14,500 acres, of which amount about 6,700 acres have been irrigated. The Fort Shaw unit has an irrigable area of about 16,000 acres. There will be then a total irrigable area below the mouth of Willow Creek of about 30,500 acres, for the irrigation of which there will be required approximately 61,000 acre-feet of water.

Table 4 gives, for the years for which records are available, the estimated amounts of water which would have been available from the South Fork of Sun River and from Willow Creek, after deducting sufficient quantities for supplying

prior rights on these streams, and the estimated balance which would have been required from the North Fork of Sun River in order to supply the 61,000 acre-feet required for the irrigation of lands on Sun River below the mouth of Willow Creek.

Table 5 gives, for the years for which records are available, the estimated supply from the North Fork of Sun River available for lands on the north side of the river after deducting such quantities as would have been required to give lower diversions a full supply.

As heretofore stated, it is proposed to divert Bowl Creek into the head of Sun River. The drainage basin of Bowl Creek above the point of diversion has an area of about 9 square miles ranging in elevation from 6,500 feet to 8,000 feet above sea level. It is estimated that the average run-off per square mile of this area will be 25 per cent greater than the average run-off per square mile of the basin of the north fork of the North Fork. On this assumption, the probable run-off for the years 1905 to 1910, inclusive, would have been as given in Table 6. The high altitude of the Bowl Creek drainage basin will bring its maximum run-off considerably later than the maximum flood period of the North and South Forks of the North Fork, and will facilitate the storage of the run-off in the Warm Springs Reservoir.

The winter flow of the North Fork of the North Fork and of the South Fork of the North Fork will be stored in the Warm Springs Reservoir. It is assumed that the irrigation period will begin about April 1 and continue until about October 31, with maximum requirement in June, July, and August. Records of stream flow of the North Fork show that, ordinarily, the natural flow continues comparatively low during April. If conditions indicate a large run-off, the winter flow may be returned to the river for diversion into the several canals before the beginning of the flood period, thus leaving the reservoir in condition to retain the maximum quantity during the period of greatest discharge.

The proposed capacity of the north supply canal is 2,000 second-feet and that of the south supply canal 1,100 second-feet. After April 1, then, the entire flow of the North Fork can be diverted into these canals except during such periods as the discharge exceeds 3,100 second-feet and, in case no water is required for the Willow Creek Reservoir, the entire flow can be diverted into the north supply canal except during such periods as the discharge exceeds 2,000 second-feet. A comparison of the last columns in Tables 3 and 4 shows that a larger quantity of water from the North Fork could have been stored each year in Willow Creek Reservoir than would have been necessary to supply the requirement. Any water furnished from the North Fork to Willow Creek Reservoir will be delivered either during the winter season from accretions below the Warm Springs Reservoir or during periods of maximum flood when Warm Springs Reservoir is full and the North Supply Canal unable to handle the flow of the stream remaining after allowing sufficient water to pass to supply the rights of canals below. The inability to utilize any part of the available water can result only from the Warm Springs Reservoir being full at such time as the normal flow of the stream at the diversion works of the supply canals, after deducting water required for canals diverting below, exceeds the capacity of the supply canals, or at such time as Willow Creek Reservoir is full and the flow exceeds the capacity of the North Supply Canal after providing for lower diversions.

In Table 7 are given, for the years for which records are available, the quantities from the flow of the North Fork available for north-side lands, the quantities which could have been diverted into the North Supply Canal or stored in the Warm Springs Reservoir, and the estimated surplus above storage and diversion capacities which would necessarily have had to be diverted into the South Supply Canal or would have passed on downstream.

The water supply from Bowl Creek will also be available for north-side lands. However, during ordinary years the supply from this stream during the flood period can not be so utilized as the storage and diversion capacities will be exceeded by the flood discharge of the North Fork. It will be in years of comparatively low flow that the Bowl Creek flood supply can be best utilized and will be most useful. In 1905, 1906, and 1910, the entire estimated annual run-off of Bowl Creek could have been stored in the Warm Springs Reservoir for use at such times as required. In 1907 to 1909, inclusive, it is probable that but a small part of the flow could have been utilized, as the flow of the North Fork was in excess of the storage and diversion capacities. The estimated annual run-off for the years 1905, 1906, and 1910 is shown as supplied to north-side

lands, while the estimated run-off for the years 1907, 1908, and 1909 is omitted for reasons stated above.

In addition to the water diverted through the North Supply Canal for north side lands, there will be available for lands under the Teton Canal and the Benton Lake unit, the run-off of Deep Creek and its tributary, Willow Creek, both of which are tributary to the Teton River.

As no discharge measurements have been made of the flow of Deep Creek and Willow Creek, an estimate of the probable run-off has been made by a comparison of these streams with the South Fork of Sun River. Willow and Deep Creeks resemble the South Fork as regards the situation, elevation, and topographic features. It would seem that their run-off would be approximately proportional to their drainage areas. The total drainage area of Willow Creek and Deep Creek is approximately 240 square miles, while that of the South Fork is approximately 87 per cent of this area. On this basis, the probable run-off of Willow and Deep Creeks has been estimated for the years 1905 to 1910, inclusive, and the estimated quantities are given in Table 8.

In Table 8 are given, for the years for which records are available, the quantities from the North Fork which could have been delivered to the north side lands either by direct diversion of the normal flow or by storage in Warm Springs Reservoir and subsequent diversion, the quantities from Bowl Creek which could have been delivered to north side lands, the quantities available from Deep and Willow Creeks for lands under the Teton Canal or the Benton Lake unit, and the total quantities which could have been delivered to north side lands from all of these sources. From this table it will be seen that north side lands could have been furnished with an abundant supply during the years 1907, 1908, and 1909, and with practically a full supply in 1910. Considerable additional supply could have been obtained in the spring of 1910 from cross drainage tributary to the long one-bank main canals. This amount is difficult to estimate, but it is certain that it would have materially increased the available supply.

The years 1905 and 1906 were years of extraordinarily low run-off. Measurements of stream flow have not been made for a sufficient number of years to show the probable recurrence of such years of low flow. During such years there would not have been a sufficient supply, after providing water for the Fort Shaw unit and for appropriations prior to those of the United States, to have furnished a full supply to the 306,000 acres on the north side of Sun River. It will be a number of years, however, before works can be constructed to cover the entire area proposed for irrigation. In the meantime, measurements of stream flow can be continued and the lands for which works are constructed can be limited to such area as may be decided most practicable. The minimum year should not be taken as determining the amount of land to be irrigated unless such minimum flow is of frequent recurrence. It is believed that years having flow similar to 1905 and 1906 are of very infrequent occurrence and that further stream measurement will show that the irrigation of approximately 300,000 acres on the north side of the river is feasible.

TABLE 1.—*Estimated supply in acre-feet from the North Fork of Sun River.*

	1905	1906	1907	1908	1909	1910
Estimated run-off of the North Fork of the North Fork for the years [1]	164,000	166,000	359,000	354,000	330,000	283,000
Estimated run-off of the South Fork of the North Fork, February to November, inclusive [2]	122,000	111,000	269,000	266,000	246,000	210,000
Estimated run-off of the North Fork below Warm Springs Reservoir, February to November, inclusive [3]	70,000	64,000	134,000	152,000	141,000	120,000
Water available for use by the United States after deducting 46,000 acre-feet for supplying prior rights	310,000	295,000	716,000	726,000	655,000	567,000

[1] 45 per cent of the flow at the gauging station for like period.
[2] 35 per cent of the flow at the gauging station for like period.
[3] 20 per cent of the flow at the gauging station for like period.

TABLE 2.—*Estimated supply in acre-feet from the South Fork of Sun River, Apr. 1 to Oct. 31.*

	1905	1906	1907	1908	1909	1910
Estimated run-off	32,200	32,000	78,000	106,000	130,000	11,000
Water available for use by the United States after deducting 11,500 acre-feet for supplying prior rights	20,700	20,500	66,500	94,500	118,500	.....

TABLE 3.—*Estimated supply in acre-feet from Willow Creek and amount in acre-feet required from the North Fork of Sun River to fill Willow Creek Reservoir to its full capacity of 84,300 acre-feet.*

	1905	1906	1907	1908	1909	1910
Estimated run-off for the year	10,000	8,000	25,000	25,000	35,000	11,000
Water available for storage and use by the United States after deducting 2,000 acre-feet for supplying prior rights	8,000	6,000	23,000	23,000	33,000	9,000
Balance of Willow Creek Reservoir capacity which would have been available for the storage of water from the North Fork, assuming all Willow Creek flow to be stored	76,300	78,300	61,300	61,300	51,300	75,300

TABLE 4.—*Estimated available supply from South Fork and Willow Creek and estimated balance required from the North Fork to supply 61,000 acre-feet for lands for which water will be taken from Sun River below the mouth of Willow Creek.*

Year.	Estimated supply from South Fork (from Table 2).	Estimated supply from Willow Creek (from Table 3).	Balance required from the North Fork.
1905	20,700	8,000	32,300
1906	20,500	6,000	34,500
1907	66,500	23,000	.....
1908	94,500	23,000	.....
1909	118,500	33,000	.....
1910	.....	9,000	52,700

TABLE 5.—*Estimated supply, in acre-feet, from the North Fork of Sun River available for lands on the north side of Sun River.*

	1905	1906	1907	1908	1909	1910
Total estimated available supply from the North Fork after deducting water required for prior rights on North Fork (from Table 1)	310,000	295,000	716,000	726,000	655,000	567,000
Required for lands on Sun River below the mouth of Willow Creek (Table 4)	32,300	34,500	.....	.....	.....	52,000
Balance available for lands on north side of Sun River	277,700	260,500	716,000	726,000	655,000	515,000

TABLE 6.—*Estimated supply in acre-feet from the North Fork of the Sun River and from Bowl Creek available for lands on the north side of the Sun River.*

	1905	1906	1907	1908	1909	1910
Estimated supply from the North Fork available for north-side lands (from Table 5)	277,700	260,500	716,000	726,000	655,000	515,000
Estimated run-off from Bowl Creek	8,000	8,000	19,000	19,000	15,500	12,500
Total	285,700	268,000	735,000	745,000	670,000	527,500

TABLE 7.—*Estimated supply in acre-feet from the North Fork of the Sun River available for north-side lands, estimated quantities which could have been diverted into the north supply canal or stored in Warm Springs Reservoir for subsequent diversion, and estimated quantities which could not have been so diverted nor stored owing to the limited capacity of reservoir and supply canal.*

	1905	1906	1907	1908	1909	1910
Estimated supply available from North Fork for north-side lands (from Table 9).	277,700	260,500	716,000	726,000	655,000	515,000
Estimated quantities which could have been diverted into north supply canal or stored in Warm Springs Reservoir	277,700	260,500	650,000	627,000	632,000	515,000
Quantities which could not have been so diverted or stored	.....	.....	66,000	99,000	23,000	.....

TABLE 8.—*Total available supply for north-side lands.*

	1905	1906	1907	1908	1909	1910
Quantities from the North Fork which could have been diverted into the north supply canal or stored in Warm Springs Reservoir for subsequent diversion (from Table 7)	277,700	260,500	650,000	627,000	632,000	515,000
Quantities from Bowl Creek which could have been diverted into north supply canal or stored in Warm Springs Reservoir for subsequent diversion	8,000	8,000	.....	.....	.....	12,500
Quantities from Deep Creek and Willow Creek available for lands under the Teton Canal	37,000	37,000	90,000	130,000	152,000	13,000
Total for north-side lands	322,700	305,500	740,000	757,000	784,000	540,000

APPENDIX TO SECTION XIII.

LOWER YELLOWSTONE DIVERSION DAM.

1. *Description.*—This dam is a rock-filled, timber and pile, overfall dam with concrete abutments, one of which forms the head gates of the canal. The crest is straight, measuring 700 feet between abutments; the width of base is 50 feet 4 inches; the maximum elevation of crest above the original river bed is about 12 feet, and above the low-water surface (of 1904) 3.5 feet. The abutment on the right bank is a straight buttressed wall of reenforced concrete. From this abutment a small earth dike with rock-paved slopes, was constructed to connect the abutment with a hillock which is never under water, the object of the dike being to prevent the scouring of a channel around the abutment during ice jams. The ordinary floods will pass over the dam with a maximum depth on the crest of about 8 feet, but at times, due to the formation of ice gorges below, there may be a depth on the crest of 25 feet.

2. The dam consists of seven rows of round piles and an upstream and a downstream row of triple-lap sheet piling. The piling is well tied together with longitudinal and transverse timbers, and the space between the piles is filled with rock. The upstream face is sloping and has a decking of 12 by 12 inch transverse timbers laid in contact. The top and front face of the dam form an ogee section, the decking on this part of the dam being formed of 12 by 12 inch longitudinal timbers laid in contact. To the decking on this face of the dam 1 by 4 inch iron straps, spaced 2 feet between centers measured longitudinally, are secured. The decking of the apron is of 8 by 12 inch timbers laid in contact and perpendicular to the axis of the dam. The toe of the apron is higher than its intersection with the lower face of the dam, the object of this arrangement being to retain a pool of water on the apron when the flow over the dam has ceased. Timber was selected as the material for the superstructure of this dam, because of its being the cheapest and because it was known that the dam would be constantly wet, for several years at least, and therefore the timber would not be liable to decay, it being expected that when, by an increased use of water higher up the river, the dam becomes exposed, the timber decking must be replaced, which can be done with concrete slabs at a relatively small cost.

3. *Headworks.*—The combined headworks and abutment is a massive concrete structure with a height of 45 feet 6 inches, a width at base of 31 feet 6 inches, and a width at crest of 11 feet. The work consists of a straight wall, 163 feet 4 inches long, and two return walls connecting with the high bank. These walls have lengths respectively of 83 feet 9 inches, and 80 feet. There are 11 circular culverts in the wall, each 5 feet in diameter, closed by sliding cast-iron gates. The combined capacity of these openings with the water surface at the crest of the dam is considerably greater than the capacity of the main canal, but the supervising engineer stated that "the area provided is only sufficient to insure the filling of the canal during the probable future low-water discharge of the Yellowstone River, which will, in a few years, at the present rate of appropriations, be materially less than at present. It is likely that within 10 years the openings in this structure may not be much in excess of the actual requirements."

4. *Pile driving.*—The subsoil of the dam is shale and sandstone, with some gravel, and it proved to be a very difficult material into which to drive timber piles. An average penetration of 20 feet was, however, secured. On account of the difficulty encountered in driving the triple-lap sheet piling and the small penetrations obtained in some places, the timber piling at these places was reinforced by steel sheet piling driven in contact with it. During the construction of the dam a large number of round piles had to be pulled on account of drift collecting against them during a flood in the river, causing considerable scour in the bed of the river and endangering the work. After the flood subsided these piles were redriven and the dam finished.

5. *Costs.*—The following is a statement of the costs of this work, as furnished by the local office:

Headworks, total cost	$66,131.33
Dam	333,105.03
Total	399,236.36

6. Based on experience elsewhere this cost appears very high. It is thought that a dam equally secure and equally suitable could have been built following some cheaper type for a much more reasonable expenditure. Possibly, also, a location could have been selected that would have obviated the construction of the dam, taking the water direct from the river by suitable headworks as in the Huntley project.

7. It is stated by the supervising engineer that the fact that they were under necessity of prosecuting the work in midwinter at temperatures of 45 degrees at times, added perhaps 100 per cent to the cost, and that the combination design was adopted as giving almost absolute certainty against being carried away. He states also that the possibility of dispensing with the dam was considered but rejected mainly on account of the lower level at which the headworks would have to be placed, necessitating a much longer useless length of main canal and much heavier excavation, as well as a reduction in the acreage which could be reached by the canal.

Appendix to Section XIV.

NORTH PLATTE PROJECT.

[Duty of Pathfinder Reservoir, by A. P. Davis, Chief Engineer.]

The available water supply for the North Platte Valley is indicated by existing records of stream flow as follows:

Orin Junction, Wyo., 1896 to 1899, inclusive.

Guernsey, Wyo., from June, 1900, to 1908, inclusive.

Whalen, Wyo., for 1909 and 1910.

The above observations can be reduced to discharge at a common point with small error.

Alcova, Wyo., 1904 and 1905.

Pathfinder, Wyo., 1905 to 1910 inclusive.

The observations for Alcova and Pathfinder may be taken as practically the same point as there is little difference in drainage area.

An effort has been made to reach a comparison of percentages among these various stations in order to complete unfilled portions of the record from 1896 to date.

Most of the observations of stream flow omit the winter months, but as these are months of low flow and little fluctuation the observations may be supplied without important error by inspection of the tables, and this has been done.

Rainfall observations have been compiled for Saratoga and South Pass City, in the basin of the North Platte, and Waterdale, Laramie, Fort Laramie, and Lander, outside of the basin but sufficiently close and representative to be of some value as indicating the precipitation in the basin itself. The stations of Laramie and Fort Laramie are in the basin of the Laramie River, which empties into the North Platte below the lowest diversion of this river by the Reclamation Service. Lander is to the north in the Big Horn Basin, and Waterdale is in the basin of the South Platte. The records for Saratoga and South Pass City are so badly broken that their utility is greatly impaired. The rainfall observations have been tabulated by years, ending September 30, as precipitation after that date affects the discharge of its own calendar year much less than the year following.

In the years 1905 to 1908 coincident odservations of stream flow were made at Pathfinder and at Guernsey.

During 1909 and 1910 coincident observations were made at Pathfinder and Whalen, and as the discharge was practically the same at Guernsey and at Whalen the years 1905 to 1910 can be taken as indicating the relative percentage of run-off at Pathfinder and at Guernsey.

The mean of these percentages by months is as follows, taking Guernsey as 100 per cent:

Table I.—*Comparative discharge at Pathfinder and Guernsey.*

Months.	Pathfinder.	Guernsey.	Percentage Pathfinder of Guernsey.
	Acre-feet.	*Acre-feet.*	
January, 1910	37,796	40,474	94
February, 1910	20,564	34,506	59
March (3 years)	90,038	115,933	78
April (4 years)	137,364	178,112	77
May (6 years)	308,976	331,427	93
June (6 years)	511,858	559,295	91
July (6 years)	195,976	270,392	73
August (6 years)	59,582	138,318	43
September (5 years)	38,482	67,410	57
October (5 years)	37,353	75,454	49
November, 1909	44,688	60,114	74
December, 1909	33,572	47,268	71
Total	1,446,249	1,918,703	76

Using the above percentages the discharge for Pathfinder is extrapolated for the years 1896 to 1903, inclusive, and the observations at Alcova are taken for 1904 as showing the flow at Pathfinder.

We thereby have discharge values from 1906 to 1910, inclusive, for Pathfinder and Guernsey as shown in the following table, which also shows for four successive years the flow of the Laramie River at Uva, near its mouth, for the months of May and June. This flow represents only a small fraction of the flow of the Laramie River, the major part being diverted above Uva.

The flow given would be available for the satisfaction of prior rights below the interstate canal.

The table also gives for the five years of actual synchronous observations, the difference for May and June, showing the run-off for those months of the area between Pathfinder and Guernsey.

This will be used later.

In each case the year ending September 30 is taken:

TABLE II.—*Observed and estimated discharge of North Platte River.*

Year ending Sept. 30—	Pathfinder.	Orin.	Difference.	Summer flow, Laramie, at Uva, May and June.	Rain.[1]	Rain.[2]
1896	[3] 966,000	1,200,000	234,000	30,000	14.85	.....
1897	[3] 1,895,000	2,239,000	345,000	139.000	12.55	.....
1898	[3] 982,000	1,184,000	202,000	64,000	13.43	.....
1899	[3] 3,022,000	3,851,000	829,000	233,000	12.34	.....
1900	[3] 917,000	[4] 1,099,000	182,000	.....	16.15	12.95
1901	[3] 1,333,000	[4] 1,561,000	228,000	.....	12.61	24.56
1902	[3] 942,000	[4] 1,110,000	168,000	.....	11.22	10.22
1903	[3] 1,228,000	[4] 1,494,000	266,000	.....	12.52	14.31
1904	[5] 1,266,000	[4] 1,620,000	354,000	[6] 163,000	12.79	.....
1905	[5] 1,175,000	[4] 1,694,000	519,000	[6] 230,000	14.25	.....
1906	1,410,000	[4] 1,725,000	315,000	[6] 120,000	16.41	18.31
1907	1,787,000	[4] 2,408,000	621,000	[6] 261,000	13.97	16.21
1908	959,000	[4] 1,565,000	606,000	[6] 494,000	14.45	.....
1909	2,257,000	[7] 2,512,000	255,000	.....	15.33	.....
1910	929,000	[7] 1,194,000	265,000	.....	10.69	19.26
Mean	1,411,000	1,764,000	352,000	.....	.....	.....

[1] Mean of Lander, Waterdale, Laramie and Fort Laramie.
[2] Mean of Saratoga and South Pass City.
[3] 76 per cent of observed discharge at Orin or Guernsey.
[4] At Guernsey.
[5] Measured discharge at Alcova.
[6] Between Pathfinder and Guernsey, May and June only.
[7] At Whalen.

It will be noted that six years in the record show less than 1,100,000 acre-feet run-off at Pathfinder and that the low years contained in this record never occur consecutively. This condition is favorable for utilizing the surplus storage capacity of the Pathfinder Reservoir. The last year in the record, 929,000 acre-feet, is the year 1910, which is pronounced by settlers the driest year ever known, and it seems to consider this near the minimum, although the record indicates an estimated flow for 1900 slightly lower, and the record at Saratoga indicates a lower rainfall in 1902.

There are many claims to the waters of the North Platte that antedate Government filings, but only a portion of these have been actually applied to beneficial use.

An adjudication of these has recently been made by the State engineers of Wyoming and Nebraska, amounting to 463 cubic feet per second in Wyoming and 4,618 feet in Nebraska. The adjudication for Wyoming may be fairly reasonable, but that for Nebraska is evidently excessive and sheds little light upon the amount that must be allowed to pass the Government diversion dam. For example, 1801 second-feet were adjudicated to the region east of Bridgeport, while only 100 second-feet were demanded there last year, the driest for many years. Of the adjudicated areas, both above and below Bridgeport, a large portion is swamp land in the North Platte Bottoms, and part of the necessary water is furnished by return seepage from the old irrigated lands. From an intimate knowledge of the valley the project engineer expresses the

opinion that 2,000 second-feet will cover all existing valid prior rights. The Nebraska adjudication is of no force in Wyoming where the proposed diversions are located, and the adjudication made would not stand in a Federal court. Nevertheless, it would hardly be safe to ignore it at the present time.

Of the total adjudication it is believed to be very conservative to assume that no more than 3,000 cubic feet per second will be actually demanded, and this, of course, only during the time when the natural flow of the river is furnishing this amount. When it falls below this amount the later rights must go short unless they arrange for stored water from the Government reservoirs.

The following table shows the dates at which the river declined to specified discharges in the period of record:

Flow of Platte at Guernsey on dates mentioned.

Year.	5,000 second-feet.	3,000 second-feet.	2,000 second-feet.
1902	June 22...	June 22...	July 1.
1903	June 29...	July 11....	July 16.
1904	June 27...	July 13....	July 18.
1905	June 30...	July 11....	July 22.
1906	June 26...	July 25....	July 26.
1907	July 12....	July 26....	Aug. 7.
1908	June 26...	July 10....	July 13.
1909	July 14....	July 20....	Aug. 5.
1910	May 18....	June 10...	June 20.

On the above assumption the Reclamation Service may store at Pathfinder only such amounts as are in excess of the needs of the canals using 3,000 second-feet in the height of the season. After the river discharge declines below 3,000 cubic feet per second, which usually occurs in July, the entire flow of the river must be allowed to flow through the reservoir in addition to the draft for reclamation uses. The irrigation season usually closes about October 1, and the little water needed after that date may be obtained from the run-off and seepage below Guernsey. The amounts that would, under these assumptions, have been released from storage as the river declined is given for five years in the following table:

TABLE III.—*Water to release from reservoir to satisfy prior rights after July 1.*

	1904	1905	1906	1907	1908	1909
July	110,000	108,000	137,000	180,000	122,000	150,000
August	36,000	37,000	41,000	84,000	75,000	80,000
September	23,000	16,000	39,000	35,000	33,000	70,000
Total	169,000	161,000	217,000	299,000	230,000	300,000
Less excess flow above Guernsey	.....	.....	70,000	90,000	10,000	.....
Net amount	169,000	161,000	147,000	209,000	220,000	300,000

The item "Less excess flow above Guernsey" refers to the inflow between Pathfinder and Guernsey while the flow at Guernsey is above 3,000 second-feet.

The region furnishing water to the North Platte Valley above Gering may be considered in four parts:

1. The region above Pathfinder tributary thereto; drainage area 12,000 square miles. Observations of stream flow at or near this point cover seven years, from 1904 to 1910, given in Table II.

2. The region below Pathfinder and above Guernsey, with an area of 4,240 square miles, from which the runoff can be obtained by comparing the measurements at Pathfinder with those at Guernsey. By means of regulation at Guernsey this can be made available. (See Table II.)

3. The drainage basin on Laramie River above Uva, with an area of 3,180 square miles, for which we have observations of the flow at Uva for four years, 1896 to 1899, inclusive. Most of the run-off of Laramie River is diverted above Uva for irrigation, and the measured discharge is the residue and return

seepage at that point, and is available for the satisfaction of water rights below the mouth of the Laramie. (See Table II.)

4. The portion of the basin below Guernsey and above Gering, exclusive of the Laramie above Uva. This area is 4,920 square miles. In this stretch of the river most of the ditches having prior rights divert water. The best available data for the run-off of this region is by comparison with the discharge from the region between Pathfinder and Guernsey. The measurements at the latter points show by comparison the run-off of this part of the basin in excess of diversions. The region between Guernsey and Gering is similar in topography, but lower in altitude, with a lighter rainfall, but is known to contribute an important supply in the irrigation season. As the drainage area is larger, it is believed, to be conservative, to estimate its drainage to be equal to that between Pathfinder and Guernsey less the diversions in that region, and this estimate is here used.

During the month of June it is expected that for prior rights the maximum quantity would be required throughout the month, 3,000 second-feet for 30 days, or about 180,000 acre-feet. In May a less amount is required, say 160,000 acre-feet, making a total of 340,000 acre-feet required to satisfy prior rights to June 30. This could be supplied from the following sources:

Water for prior rights in May and June:	
From Laramie River, value for 1896 (Table II)	30,000
Other drainage below Guernsey (estimated)	120,000
Run-off between Pathfinder and Guernsey (Table II, 1906)	120,000
Balance from reservoir	70,000
Total supply for May and June priorities	340,000

The draft of 70,000 added to the 220,000 (see Table III) passing through the reservoir after July 1 gives a total of 290,000 acre-feet to be deducted from the supply above Pathfinder to satisfy prior rights.

From the above we may assume that the amount of water that must pass the Pathfinder Reservoir, which cannot on account of prior rights be held there, is 300,000 acre-feet per annum.

The large required amount indicated in Table III for the year 1909 is due to the excessive flow of that year, and would have been wasted in any event, because of a full reservoir. It may, therefore, be disregarded. Aside from this, the highest year is 1908, in which 220,000 acre-feet would have passed through the reservoir after July 1. Little irrigation is done in April, and this in the latter part. This period is one of rather large run-off from the low country, and there would always be plenty of water for all prior rights in April from the run-off below Pathfinder.

The contracts on the North Platte project allow a water supply limited to beneficial use of not to exceed 2½ feet in depth. As not all land with water right is under cultivation at any one time, and as much grain and other crops of short season will always be grown, it seems safe to assume that the actual average consumption of water will be considerably less than 2½ feet measured on the land. To furnish this we may assume that it will be necessary to provide 3 acre-feet in the reservoir for every acre holding full water right.

In addition to prior rights above mentioned, it is desirable to provide a full water supply to the following lands:

	Acres.
Interstate Canal	115,000
Goshen Park high line	150,000
Fort Laramie Canal	50,000
Total	315,000

In addition to the above there is an indefinite area of land in private ownership above Guernsey and under the Tristate Canal aggregating over 100,000 acres, which may or may not apply for reservoir rights in the future under the terms of the reclamation act. The purpose of this discussion is to determine as approximately as possible what acreage we can safely undertake to water in order to proceed along a rational plan.

Of the above area under the Interstate Canal, 30,000 acres is to be watered from small reservoirs to be constructed on the project which will be filled partly by waste water from that canal, but mainly from the run-off of the area below Pathfinder in the fall and early spring. It is believed to be safe, there-

fore, to eliminate this area from that to be supplied from the Pathfinder Reservoir.

In the ultimate development there will be considerable return seepage from the upper lands available for the Interstate Canal and for the prior rights below, and though no data on this point is available, it seems conservative to estimate that this will be sufficient for the irrigation of about 30,000 acres. The deduction of this area leaves a total of 255,000 acres to be supplied with irrigation water from the contemplated Government works.

The year ending September 30, 1900, as given in Table II, is the lowest in the record, and is followed by a year of less than average supply, and this in turn by one of the lowest in the record. This constitutes the most severe combination in the record.

The heavy discharge in the year 1899 insures a full reservoir June 30, 1900. According to our assumptions, prior rights would have required after that date 220,000 acre-feet of water, and 315,000 acres in the Government projects would have required 60 per cent of a full supply, or 567,000 acre-feet. This would have left 313,000 acre-feet in the reservoir. We would have had—

Remaining in reservoir Sept. 30, 1900		313,000
Run-off for 1901		1,333,000
		1,646,000
Evaporation	45,000	
Prior rights	300,000	
Irrigation draft	945,000	
		1,290,000
Remaining in reservoir Sept. 30, 1901		356,000
Run-off for 1902		942,000
		1,298,000
Evaporation	50,000	
Prior rights	300,000	
Irrigation draft	945,000	
		1,295,000
Balance		3,000

According to the above we may safely construct both the Goshen Park line and the Fort Laramie Canal and have sufficient water to supply 30,000 acres of private land and as much more as may be supplied from the return seepage water from the above systems. The demand for this is developed only to a very small extent as yet.

If two or more years in succession should occur with discharge as low as that of 1900, there would still be more than a 70 per cent supply, which would not be disastrous, but is such a shortage as we should expect at long intervals under a proper development. Also, the same acreage may be served if the minimum year should furnish a supply much smaller than any now of record, provided it does not occur two years in succession.

In case of a large private demand for stored water, or that some of the above assumptions are more favorable than facts will justify, it may be found desirable to omit the Fort Laramie Canal, or to build it of smaller dimensions than now contemplated. In this there is such a margin that there can be no doubt of the water supply being sufficient for the Goshen Park project if desirable to use it there.

It is believed, however, that the greatest error in the above assumptions is the large amount set aside for prior rights, namely, 3,000 cubic feet per second. If this can be held down to 2,000 second-feet, according to the estimate of the project engineer, it will add about 80,000 acres to the above duty.

Appendix to Section XV.

TRUCKEE-CARSON PROJECT.

WATER SUPPLY.

1. The water supply for this project is obtained from the Carson and Truckee Rivers, a canal with a capacity of 1,200 second-feet, diverting the flow from the latter to the Carson.

2. The project provided for the regulation of the flow of the Truckee River by means of storage at Lake Tahoe, and the construction of storage reservoirs on the Lower Carson River, known as the Carson Reservoir, with a capacity of 290,000 acre-feet, and Alkali Flat Reservoir, the capacity of which is at the present time undetermined, but will be approximately 228,000 acre-feet.

3. The following condensed statement of the available supply and irrigation requirements for the Truckee-Carson project has been prepared for the board by the supervising engineer:

"The average flow of the Truckee River at Vista, Nev., a gauging station a few miles above the Derby Dam but below the irrigated lands at Reno, is 880,000 acre-feet per annum during the period 1900 to 1907, inclusive. Excepting about 30 second-feet during the irrigation season, all of this flow is available for diversion for the Truckee-Carson project.

"The average flow of the Carson River at Empire, Nev., a point a few miles above the proposed Carson Dam, is 364,000 acre-feet per annum after making deduction for all vested rights on the river. This amount is, therefore, all available for use on the Truckee-Carson project.

"By regulating the flow of the Truckee River by means of storage at Lake Tahoe it will be possible to deliver water through the main Truckee Canal into the proposed Carson Reservoir to an annual amount of 710,000 acre-feet, This is the net amount after making appropriate deductions for vested rights along the Truckee River and the irrigation supply for lands under the Truckee-Carson project between the Derby Dam and the Carson Dam.

"There will therefore be available in the Carson Reservoir an average annual supply of 1,070,000 acre-feet, made up of 360,000 acre-feet from the Carson and 710,000 acre-feet from the Truckee.

"In order to irrigate 172,000 acres below the Carson Dam there will be required 602,000 acre-feet of water, allowing 3.5 acre-feet per acre. Of this amount 312,000 acre-feet can be turned directly from the Truckee main canal into the Carson River and thence onto the irrigable lands without utilizing any storage. The balance of 290,000 acre-feet will have to be supplied from storage on the Carson River.

"The 290,000 acre-feet of storage water can be derived from deliveries from the Truckee main canal into the Carson Reservoir during the nonirrigating season, or from the natural flow of the Carson River into the Carson Reservoir, or both. In practical operation it will probably be found advantageous to use Carson River water as far as it will go, making up the deficiency by deliveries from the Truckee main canal during the nonirrigating season. This will permit the service of the main canal to be discontinued during a considerable portion of the nonirrigating season.

"Hydrographic studies show that at no time during a nine-year period over which records extend would the Carson River Reservoir have been seriously depleted or reduced below a storage of 100,000 acre-feet.

"The ultimate construction of a reservoir at Alkali Flat will utilize much of the surplus flow of the Carson River for irrigating lands in Churchill Valley.

"It will be noted that apparently a considerable excess supply of the Truckee and Carson Rivers exists. The period over which records extend apparently includes a cycle of excessive precipitation. The California records show that during the seventies a prolonged period of excessive drouth occurred much in excess of anything that had previously or has since been experienced. The apparent margin of safety in the supply works for the Truckee-Carson project as at present designed need not, therefore, be considered as being in any way excessive, as there is a distinct possibility that should a prolonged period of drouth, as before mentioned, recur the supply will not prove more than adequate.

"Accompanying this statement is a tabulation entitled 'Table of requirements and available supply for irrigating various areas of land below Carson Dam.' The land below Carson Dam includes 172,000 acres made up of the first unit,

districts 3, 4, and 5, and Carson Lake extension. The two remaining branches of the project, viz, Pyramid Lake extension and Churchill Valley, would be watered directly from the Truckee main canal or from the Alkali Flat Reservoir on the Carson River."

4. The above statement assumes a regulated flow in the Truckee River. About a year ago an agreement between the power company controlling the outlet to Lake Tahoe and the Reclamation Service was drafted, under the provisions of which the desired regulation of the Truckee River was to be secured at a very nominal cost to the project, approximately $20,000. This agreement has been before the Secretary of the Interior for some time, but has not received his approval. The regulation of the Truckee River could probably be accomplished by storage elsewhere than in Lake Tahoe, but at a largely increased cost. Some agreement with this company, even at a greater cost to the Truckee-Carson project, is desirable.

5. An examination of the hydrographs of the Truckee and Carson Rivers shows 1908 as a year of minimum flow, and the following table, based upon conditions that year, indicates that, excluding Alkali Flat Reservoir and the land that can be irrigated directly from it in Churchill Valley, only 150,000 acres could have been irrigated in that year had the flow of the Truckee River not been regulated:

Months.	Mean monthly flow.			Monthly demand for 150,000 acres.	Balance required from Carson Reservoir.
	Truckee River less 20 per cent loss in canal.	Carson River.	Combined flow.		
	Second-feet.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*
April	920	450	1,370	882	.....
May	536	570	1,106	1,537	431
June	496	410	906	1,941	1,035
July	272	150	420	1,878	1,458
August	248	50	298	1,708	1,410
September	216	50	266	529	263
October	336	70	406	171	.....

Being equal to 275,820 acre-feet.

6. As approximately 13,000 acres below Carson Dam has prior vested rights in the unregulated flow of the Carson River, the area under the project that could have been irrigated in this year of low run-off would not have exceeded 140,000 to 145,000 acres, exclusive of Churchill Valley, as against 192,000 acres if the Truckee River had been regulated.

7. By increasing the capacity of Alkali Flat Reservoir above that required for Churchill Valley it may be possible to secure sufficient water for the needs of this project without regulating the flow of the Truckee River, but at greater expense and with less certainty, particularly in view of the probability of a prolonged period of drought such as is said to have occurred in the seventies.

8. The regulation of the flow of the Truckee by means of storage at Lake Tahoe may not be an essential part of this project, but it is a desirable one, as it will reduce the cost per acre and insure an ample supply of water under all conditions.

Table of requirements and available supply for irrigating various areas of land below Carson Dam.

Months.	Available supply delivered from main Truckee Canal.	Monthly demand for 85,000 acres.	Balance required from Carson River.	Monthly demand for 100,000 acres.	Balance required from Carson River.	Monthly demand for 125,000 acres.	Balance required from Carson River.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
January	1,080	.....	.....	.....	.....	.....	.....
February	1,080	.....	.....	.....	.....	.....	.....
March	1,080	.....	.....	.....	.....	.....	.....
April	968	500	.....	588	.....	735	.....
May	902	871	.....	1,025	123	1,281	379
June	826	1,100	274	1,294	468	1,681	792
July	840	1,064	224	1,252	412	1,566	726
August	849	968	119	1,138	289	1,423	574
September	1,003	300	.....	353	.....	441	.....
October	1,039	97	.....	114	.....	142	.....
November	1,080	.....	.....	.....	.....	.....	.....
December	1,080	.....	.....	.....	.....	.....	.....
Total .....acre-feet..	710,000	294,000	37,000	352,000	77,500	436,000	148,000

Months.	Monthly demand for 135,000 acres.	Balance required from Carson River.	Monthly demand for 150,000 acres.	Balance required from Carson River.	Monthly demand for 175,000 acres.	Balance required from Carson River.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
January	.....	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....	.....
March	.....	.....	.....	.....	.....	.....
April	794	.....	882	.....	1,029	61
May	1,383	481	1,537	635	1,793	891
June	1,747	921	1,941	1,115	2,264	1,438
July	1,691	851	1,878	1,038	2,191	1,351
August	1,537	688	1,708	859	1,992	1,143
September	476	.....	529	.....	617	.....
October	153	.....	171	.....	199	.....
November	.....	.....	.....	.....	.....	.....
December	.....	.....	.....	.....	.....	.....
Total.....acre-feet..	467,000	176,000	525,000	219,000	612,000	293,000

Appendix to Section XXI.

WATER SUPPLY.

1. Water is obtained for this project from Link River and Lost River. Link River, which is the outlet of Upper Klamath Lake, has a drainage area of 3,100 square miles, with an average rainfall on the drainage area of about 20 inches.

2. Discharge measurements have been made continuously since August, 1904, and the results show an average annual run-off of 1,700,000 acre-feet. The mean monthly discharge for this period varies from 3,839 second-feet in April to a minimum of 1,185 second-feet in September. The lowest average daily discharge for any one month was 900 second-feet in September, 1908.

3. Upper Klamath Lake, with an area of 66,000 acres, constitutes a good natural reservoir, and at slight cost additional storage to the extent of 200,000 acre-feet can be provided.

4. An examination of the discharge measurements since 1904 indicates that with such storage no difficulty would have been had in maintaining a constant flow during the irrigating season of not less than 1,400 second-feet. There are prior rights on this river amounting to 325 second-feet, all of which is used in development of power. The requirements of the project are analyzed as follows:

Area to be irrigated.

	Acres.
Lower project uplands	37,000
Tule Lake lands	35,000
	72,000

5. On the basis of 1 second-foot for each 100 acres, 720 second-feet will be required for this area. Of this amount 100 second-feet will be furnished from Lost River, as described hereafter, and the remainder, 620 second-feet, from Link River through the main canal. For the development of power by the Reclamation Service there will be required 445 second-feet delivered through the Keno Canal, making a total diversion from Link River for the project of 1,065 second-feet. This added to the amount to which prior appropriators are entitled equals 1,390 second-feet, or practically the amount obtainable from Link River after its flow has been regulated as above described.

6. Lower Klamath marshes, if drained in accordance with the present plans, will also be irrigated with water discharging from Link River. As the point of diversion will be below the power plants there will be an abundance of water for this purpose.

7. Discharge measurements of Lost River have been made since 1904 and show an average annual run-off of 118,960 acre-feet below Clear Lake Dam, the drainage area above this point being 600 square miles. To regulate the flow of this river, Clear Lake Reservoir has been built. It has an area of 25,000 acres and an available capacity of 462,000 acre-feet. The primary purpose of this reservoir was to store the flood waters of Lost River and increase the evaporation loss therefrom so as to permit the reclamation of part of Tule Lake by evaporation, but it also serves to store water that can subsequently be used in irrigation.

8. A study of the history of this reservoir, assuming it to have been built in 1904, and assuming that commencing with the season of 1906 an annual irrigation draft had been made upon it of 75,000 acre-feet (sufficient for watering 30,000 acres) shows that during the entire period covered by the records the reservoir would have been full at no time, and that during the past four years there would, probably, not have been sufficient water for the full irrigation of the 30,000 acres. As to the effect of this reservoir upon Tule Lake, an analysis made by the Reclamation Service indicates that with a yearly evaporation of 4.65 feet the surface level of Tule Lake would have been reduced about 6 feet in a little over five years, a rate of recession that would delay for an unreasonable length of time the reclamation of submerged Tule Lake lands. To hasten this result, a diversion channel has been planned leading from Lost River to Klamath River. As to the size of this channel the following is quoted from a report by the project engineer:

"The diversion of water from Lost River through a 200 second-feet capacity channel would have lowered the surface of Tule Lake an additional 5 feet, or to a total of 11 feet in the period under consideration. Additional diversion through a 400 second-feet channel, instead of one of 200 second-feet, would have lowered the lake surface but an additional 2 feet during the same time.

"These computations may be considered as showing the most favorable conditions, as no correction has been made for the inevitable increase of discharge of Lost River due to return water from irrigation on the lower project, and from a similar source on the upper project in case the latter, eventually, should be irrigated. It is considered, however, that the fact of this return water could be offset by making the actual capacity of the drainage canal about 50 second-feet greater than the figures used for purposes of computing diversion. Some further corrections would have to be made if the computations of amount diverted through the Lost River diversion channel should be computed from daily discharge measurements, rather than from monthly totals. Such computations have been made in part, but are found to have an inappreciable effect on the general result."

9. The analysis as to what might have been accomplished during the past five years has been continued by the Reclamation Service up to and including 1913 under the assumption that the rainfall conditions for the years 1906–1909 could be applied to the succeeding four years, from which it appears that at the end of 1913 the surface of Tule Lake would have been at elevation 4,038, equivalent to a total lowering of 18 feet and to the reclamation of about 35,000 acres. Under the assumptions made this work would have required nine years from the completion of Clear Lake Dam and the Lost River diversion.

10. The studies of the Reclamation Service relative to the reclamation of Tule Lake lands contain many elements entering into the problem, such as run-off from the surrounding drainage basin, rainfall in the future, seepage from lands now being placed under irrigation, that are more or less indeterminate, and time alone can decide whether the assumptions made are warranted. That

35,000 acres of these lands can, eventually, be reclaimed in the manner proposed seems probable.

11. Water for irrigating Tule Lake lands may be obtained from Link River, or from Lost River. If the Modoc subproject is built the bulk of it will be obtained from Link River. In considering above the draft upon Link River, it was assumed that only 100 second-feet of the amount required for the Tule Lake lands would be obtained from Lost River, this amount being available in the lower reaches without trespassing upon Clear Lake storage.

12. The Modoc subproject, if constructed, will be watered from Clear Lake Reservoir. It is estimated that there will be sufficient water in this reservoir for the irrigation of from 25,000 to 30,000 acres, and as the Modoc subproject covers only 18,000 acres, there will be a balance probably sufficient to satisfy certain undetermined prior rights in Upper Langell Valley that are now in the process of adjudication.

13. The upper subproject, if constructed, will depend for its supply upon Miller Creek, the annual run-off of which averages 70,000 acre-feet, varying from a maximum of 125,000 acre-feet in 1907 to a minimum of 19,000 acre-feet in 1908. With the proposed Horsefly Reservoir, having a capacity of 55,000 acre-feet, it is reasonable to assume that there will be available not less than 40,000 acre-feet each year. Only 1½ acre-feet per acre are deemed necessary on the land. Seepage and evaporation losses are assumed by the Reclamation Service at 40 per cent, thus requiring a reservoir allowance of 2½ acre-feet per acre. At this rate there will be sufficient for 16,000 acres. These allowances are liberal and it may be found possible to subsequently increase the acreage under this subproject.

Appendix to Section XXII.

BELLE FOURCHE PROJECT.

1. *Reservoir Dam.*—This is of earth fill, without core wall, which type was adopted mainly on account of the character of subsoil and the material available for the fill. The general dimensions are: Length on top, 6,200 feet; width on top, 19 feet; maximum height, 115 feet above stream bed; side slope, 2 to 1 on the inside, except that below the concrete toe wall the slope is 5 to 1, and for the uppermost 15 feet is 1¼ to 1. On the outside the slope is 2 to 1 except for the uppermost 30 feet where it is 1.65 to 1. The downstream slope is strengthened by two berms, 8 feet wide, provided with concrete drainage gutters. The dam will contain, when completed, 1,600,000 cubic yards of earth and 45,000 cubic yards of gravel. A cut-off trench was excavated the full length of the dam along its center line, and filled with selected material. The earth fill was deposited in 6-inch layers, wetted, and rolled with a steam roller. A drawing showing the cross section of the dam is appended hereto.

2. There is considerable gypsum in the vicinity, and efforts were made to exclude it from the material used in the body of the dam, borrow pits being selected with this end in view. In the fourth annual report of the Reclamation Service it was stated that the "material of which it will be built is heavy clay and gumbo, which weighs in some places 120 pounds per cubic foot," and "a number of open borrow pits were sunk to bedrock under the proposed dam, and it was found that the distance to shale under the body of the dam was 40 feet. No continuous gravel or water-bearing strata were encountered, and the base under the dam will therefore be impervious. All borrow pits at which earth or gravel is to be obtained were carefully investigated by open test wells and borings. An examination and analysis of the earth to be used in the dam was made by H. Means, and his report showed only a small amount of soluble matter in the material from most of the borrow pits, but in two pits there was a large percentage of gypsum, and this material will not be used."

3. The methods followed in preparing the site and in depositing the fill are those used in good engineering practice. The concrete block facing on the waterside is especially substantial. It is made of slabs, 6 feet by 4 feet, and 8 inches thick, molded in a yard and later placed on a 24-inch layer of screened gravel. The facing is held in place at the foot by a concrete toe wall. The two concrete gutters on the upper and lower berms on the downstream side are well suited to their purpose. An ample spillway is provided to take care of floods,

the crest being 15 feet below the top of the dam. This spillway is semicircular in plan and 314 feet in length. The fall of the water over the crest is broken by two concrete steps, after which the water flows in a concrete-lined channel on a 4 per cent grade to the foot of the slope, and there is discharged into the river bed, which is protected against undue erosion by concrete work.

4. The capacity of the reservoir is 204,000 acre-feet. Two outlets are provided, one for the north and one for the south main canal, with capacities of 650 and 300 second-feet, respectively. The gates in each are in duplicate, those nearest the reservoir being of the piston type, while those in the rear are of the sliding type. The clear opening of the gates is 4 feet by 6 feet. The proportions used in concrete were 1 cement, 2¼ sand, and 4½ gravel.

5. *Comment.* The board deems it prudent to call attention to the relative steepness of the side slopes for the dam. Usually these slopes, especially on the upstream side, in dams of this height and character without core wall, are not steeper than 3 on 1, to avoid sloughing when the reservoir is drawn down and when under full head to keep the hydraulic grade line through the dam and subsoil from coming to the surface on the downstream slope or too near the toe. This may be accomplished with the steeper downstream slopes, but to assume that it is satisfactorily done in any particular case necessarily places great reliance on the results of the methods of construction followed and material used to obtain water-tightness in the dam, a reliance not always justified. The best practice, therefore, while using every precaution in construction, also usually adopts the flatter side slopes.

6. In the present instance, the dam has not been exposed to the full head; in fact, the water has risen to less than half the projected height. While there has been no appearance of seepage through the dam itself, there has appeared some seepage apparently through the subsoil at a point about 100 feet to one side of the maximum section and a short distance below the toe.

7. This indicates that there is some leakage through the dam or that the subsoil is more permeable than as stated in the quotation above.

8. In view of this and of the great damage the failure of the dam would occasion, it is thought that it should be carefully watched for several years to detect any signs of weakness.

9. The total cost to date has been $950,231.46, and the estimated additional cost to complete it is $166,000, or a total of $1,116,000 in round numbers. These figures include all overhead charges.

Appendix No. 1 to Section XXV.

WATER SUPPLY.

Summary of data and conclusions, final development Yakima project.

I. CAPACITY OF RESERVOIRS.

Name of reservoir.	Capacity (acre-feet).	Remarks.
Keechelus	142,000	Upper lakes, 778,000 acre-feet.
Kachess	210,000	
Clealum	426,000	
Bumping	35,000	
McAllister	115,000	Naches, 150,000 acre-feet.
Total	928,000	

Summary of data and conclusions, final development of Yakima project—Continued.

II. ACREAGE AND ESTIMATED STORAGE REQUIREMENTS.

[Based upon an irrigation season from April to October 15, inclusive, and high line acreage of 160,000. Storage movement by years given below.]

Project.	Point of diversion.	Total acres under project.	Acreage requiring storage.[1]	Mean August requirement.		Storage charge (acre-feet).[2]	Duty of storage water (acre-feet per acre).[3]
				Duty (second-feet per acre).	Diversion (second-feet).		
Kittitas	Easton	67,000	67,000	1.84	800	146,000	2.18
High Line	Teanaway	160,000	160,000	1.80	2,000	366,000	2.28
Tieton	Tieton River	34,000	34,000	1.106	320	59,000	1.73
Wapato	Union Gap	120,000	108,000	1.80	1,350	247,000	2.28
Sunnyside	do	100,000	48,000	1.80	600	110,000	2.28
Total		481,000	417,000		5,070	928,000	2.22

[1] The Sunnyside project has 650 second-feet of natural river flow. This is considered as serving 650 by 80, or 52,000 acres without storage. Also Wapato has 150 second-feet, considered as serving 12,000 acres without storage.

[2] This storage charge is computed on a basis of the acreage under each project which will require storage and the diversion per acre for the project.

[3] This may be termed the storage charge per acre.

III. PRIVATE CANALS.

All private canals above Union Gap are provided for on basis of past usage. The private canals in the lower valley will receive a sufficient quantity for their needs from return flow.

IV. PLEDGED STORAGE.

Cascade County: An allowance of 17,000 acre-feet is provided from storage as follows: July 20–31, 113 second-feet; August, 115 second-feet; September, 92 second-feet; October, 1–15. 58 second-feet.

Union Gay Irrigation Co.: The small quantity of storage due this company is considered as coming from Kittitas return flow.

V. HOLDOVER.

As the two Naches reservoirs will always have a considerable excess run-off available, no holdover should be stored in them. For the following summary the holdover has been considered as stored as follows: Keechelus, 10 per cent; Kachess, 40 per cent; Clealum, 50 per cent.

VI. KACHESS FEED CANAL.

For this scheme of development, no necessity for a feed canal from Keechelus to Kachess has arisen during the past seven years of record. Conditions might arise that would make such a canal operative; for example, if a year like 1908 had followed the year 1906. It would seem, however, that the probability of such necessity is not very great.

Summary of storage movement, by years, final development Yakima project.

[Basis of summary: Reservoir capacity and project acreage as noted on sheet 1; provision for private canals (sheet 2). Irrigation season April 1 to October 15. Storage season starts November 1. Summary from hydrographs.]

Season and reservoir.	Storable run-off.	Hold over from year previous.	Total quantity stored for season.	Storable water lost for lack of reservoir capacity.	Project.	Acreage to required storage.	Total storage (from hydrography).
1904:							
Keechelus	151,000	.....	142,000	.....	Kittitas	67,000	71,000
Kachess	199,000	.....	210,000	.....	Sunnyside	48,000	.....
Clealum	534,000	.....	426,000	.....	Wapato	108,000	306,000
Naches	.....	.....	150,000	.....	Tieton	34,000	.....
					High line	160,000	253,000
Total	.....	.....	928,000	.....	Cascade County	.....	17,000
Next season hold over	.....	.....	261,000	.....	Pass S. S. Dam	.....	20,000
Total used	.....	.....	667,000	.....	Total	417,000	667,000
1905:							
Keechelus	130,000	26,000	142,000	14,000	Kittitas	67,000	76,000
Kachess	155,000	104,000	210,000	49,000	Sunnyside	48,000	.....
Clealum	270,000	131,000	426,000	.....	Wapato	108,000	368,000
Naches	.....	.....	150,000	.....	Tieton	34,000	.....
					High line	160,000	288,000
Total	.....	261,000	928,000	38,000	Cascade County	.....	17,000
Next season hold over	.....	.....	159,000	.....	Pass S. S. Dam	.....	20,000
Total used	.....	.....	769,000	.....	Total	417,000	769,000
1906:							
Keechelus	132,000	16,000	142,000	6,000	Kittitas	67,000	94,000
Kachess	141,000	64,000	210,000	.....	Sunnyside	48,000	.....
Clealum	346,000	79,000	426,000	.....	Wapato	108,000	450,000
Naches	.....	.....	150,000	.....	Tieton	34,000	.....
					High line	160,000	333,000
Total	.....	159,000	928,000	.....	Cascade County	.....	17,000
Next season hold over	.....	.....	14,000	.....	Pass S. S. Dam	.....	20,000
Total used	.....	.....	914,000	.....	Total	417,000	914,000
1907:							
Keechelus	220,000	1,000	142,000	79,000	Kittitas	67,000	98,000
Kachess	209,000	6,000	210,000	5,000	Sunnyside	48,000	.....
Clealum	527,000	7,000	426,000	108,000	Wapato	108,000	360,000
Naches	.....	.....	150,000	.....	Tieton	34,000	.....
					High line	160,000	320,000
Total	.....	14,000	928,000	192,000	Cascade County	.....	17,000
Next season hold over	.....	.....	113,000	.....	Pass S. S. Dam	.....	20,000
Total used	.....	.....	815,000	.....	Total	417,000	815,000
1908:							
Keechelus	170,000	11,000	142,000	39,000	Kittitas	67,000	66,000
Kachess	188,000	45,000	210,000	23,000	Sunnyside	48,000	.....
Clealum	447,000	57,000	426,000	78,000	Wapato	108,000	258,000
Naches	.....	.....	150,000	.....	Tieton	34,000	.....
					High line	160,000	240,000
Total	.....	113,000	928,000	140,000	Cascade County	.....	17,000
Next season hold over	.....	.....	327,000	.....	Pass S. S. Dam	.....	20,000
Total used	.....	.....	601,000	.....	Total	417,000	601,000
1909:							
Keechelus	120,000	33,000	142,000	11,000	Kittitas	67,000	77,000
Kachess	146,000	131,000	210,000	67,000	Sunnyside	48,000	.....
Clealum	307,000	163,000	426,000	44,000	Wapato	108,000	361,000
Naches	.....	.....	150,000	.....	Tieton	34,000	.....
					High line	160,000	293,000
Total	.....	327,000	928,000	122,000	Cascade County	.....	17,000
Next season hold over	.....	.....	160,000	.....	Pass S. S. Dam	.....	20,000
Total used	.....	.....	768,000	.....	Total	417,000	768,000
1910:							
Keechelus	227,000	16,000	142,000	101,000	Kittitas	67,000	102,000
Kachess	228,000	64,000	210,000	82,000	Sunnyside	48,000	.....
Clealum	590,000	80,000	426,000	244,000	Wapato	108,000	416,000
Naches	.....	.....	150,000	.....	Tieton	34,000	.....
					High line	160,000	360,000
Total	.....	160,000	928,000	427,000	Cascade County	.....	17,000
Next season hold over	.....	.....	13,000	.....	Pass S. S. Dam	.....	20,000
Total used	.....	.....	915,000	.....	Total	417,000	915,000

Appendix No. 2 to Section XXV.

M'ALLISTER MEADOWS RESERVOIR SITE.

1. The McAllister Meadows Storage Reservoir site was visited by a committee of the board on August 30, 1910.

2. This reservoir site is located on the headwaters of the Tieton River. At the present time there is no water stored in this locality, the site consisting of meadow land which it is proposed to flood by the construction of a high dam in the Tieton River, backing water up into the North and South Forks. It is expected that a spillway can be placed in a low portion of the rim of this reservoir, now occupied by Milk River, a small stream flowing into the Tieton. This site, however, has not been explored, and the construction of a spillway may involve many engineering difficulties, increasing the cost above what is now estimated. If the present plans are carried out, McAllister Meadows will be developed into the fourth reservoir, in point of size, in the Yakima project.

3. The dam site is in a narrow gorge of the Tieton River, where the width is not over 300 yards between the high rock headlands on both sides of the canyon, furnishing what appears to be excellent abutments for dam construction. Borings have been made in the dam site and drifts have been dug to develop the underlying material. It appears from these, as far as now completed, that the rock faces of the canyon on either side continue at about the present slope to great depths. The intervening space across the bottom of the canyon is filled with bowlders, broken rocks, and disintegrated material. Some borings as deep as 80 feet were made without striking any more solid material.

4. As this site is impracticable for a masonry dam, some sort of earth or rock fill dam will be necessary. This construction, and the estimates of the Reclamation Service have been based upon a structure of this type, is contingent on adequate spillway facilities, as no overflow can be permitted to take place over a dam of the character suggested.

5. This estimate the committee believes to be somewhat low, and it may be desirable to revise these figures after further examinations are made of the possible spillway sites.

6. The capacity of the McAllister Meadows Reservoir is to be 115,000 acre-feet. The maximum height of proposed dam is 150 feet, length on crest 900 feet, and the estimated cubical contents about 450,000 cubic yards.

Appendix No. 3 to Section XXV.

BUMPING LAKE RESERVOIR.

1. Bumping Lake is located in Washington, about 46 miles from Naches, the nearest railway point. The object of this reservoir is to store the flood waters of the lake for use in the Yakima project. It was visited on August 30 and 31 by a committee of the board.

2. The capacity of the reservoir is 34,000 acre-feet and the variation of water level 35 feet. The work consists in the construction of a dam across the Bumping River about one-half of a mile below the lake, the spillway, and the discharge conduit and accessories. At the time of the inspection the work was approximately 75 per cent completed and it is proposed to finish it this season.

3. The dam is of the earth-fill type, 45 feet in total height and 3,500 feet in length. The width on top is 20 feet. The side slopes are 3 to 1 on the reservoir side and 2 to 1 on the downstream side. This latter slope flattens out to 4 to 1 near the toe. In plan the dam is slightly curved to follow the high ground and reduce the embankment.

4. The materials for the fill are excavated from a borrow pit by steam shovel, loaded on small dump cars and hauled by horses on a railway to the dam site. The line from the borrow pit branches at the end of the dam into two lines, one of which follows each slope of the dam. The cars are dumped toward the center of the dam, forming two parallel embankments. The fine material is then washed down toward the center by water from pressure nozzles, thus forming a sluice-fill core, leaving the heavier gravel and bowlders to form the outside portions of the dam. The tracks are shifted as the dam rises and the core thus becomes progressively thinner and the proper slope is given to

the faces. The reservoir face is being paved with a 2-foot layer of bowlders of more or less rounded shape and of varying sizes. These bowlders are obtained in part by selection of the larger ones exposed in sluicing down the finer materials, but mainly from the spillway excavation. The subsoil is gravel, bowlders, and volcanic earth in varying proportions. Undisturbed it seems fairly compact, but is thought to be somewhat porous. The earthy part is easily eroded when exposed to water currents. Originally it was the intention to put in a core wall of puddle, but on account of the difficulty in obtaining suitable materials, the sluicing method was adopted. In addition to the excavation for the core wall, all vegetable matter was removed from the site of the dam. The right abutment is the natural soil stripped as above described. The left abutment of the dam forms part of the spillway.

5. While it was designed to have the sluice-fill core throughout the whole length of dam, owing to failure of water supply last year a portion of the dam was constructed without a sluice core. This portion, however, lies near the right end and forms the part of the dam with least height. The material as a whole is not of the best for the purpose. The earthy part, being volcanic ash, is very fine, while the remainder, forming only a small proportion, is composed of more or less rounded bowlders, none of which are very small. The water tightness of the dam depends entirely on the sluice-filled core. The embankments may be expected to wash more or less badly from rains and melting snows, where not protected. Drift and ice may also damage the interior slope. On account of the lightness of the material, seepage and erosion must be carefully watched and a protecting covering on crest and downstream slope may be necessary.

6. The outlet is through a concrete conduit under the dam near its center. It is controlled by four gates, two of which are emergency and two for regular operation. The maximum capacity of the outlet works is 1,000 cubic feet per second, while the normal discharge is to be 400 cubic-feet per second. The gates are operated by hand and are set in a concrete gate tower surmounted by a wooden gatehouse, connected with dam crest by small foot bridge. The opening given by each gate is 5 feet square.

7. The spillway is 235 feet clear length, and is designed to pass 6,000 second-feet with a crest depth of 4 feet. The cross section shows a vertical back and ogee front face, the fall being 6 feet. The fore bay is paved for some distance, and is level with the crest of the spillway, which is 10 feet below the crest of the dam. The abutments are of the buttressed reenforced concrete type. The walls are carried downstream to join the concrete lining of the discharge channel. This channel narrows to 42 feet width, where it joins a wooden flume 115 feet long discharging into the river. The bed of the river where the water falls will be protected by large bowlders. The flume as designed is of very heavy construction and is to be supported by three sets of piers, three piers in each set.

8. The concrete of the gate tower seems excellent in every way, but that of the spillway is poor. Both were made from the same brand of cement. The proportions used were 1, 2½, and 4½ of cement, sand, and gravel. The paving of the spillway floor showed effects of spring water coming up from beneath, and much of the floor is to be relaid.

9. The total estimated cost is $525,000.

Appendix to Section XXVI.

SHOSHONE PROJECT.

WATER SUPPLY.

1. The water supply for the Shoshone irrigation project, Wyoming, is derived from the Shoshone River, the flood discharge being regulated by the Shoshone Reservoir which, as now completed, has a capacity of 456,570 acre-feet.

2. The drainage basin above the reservoir contains approximately 1,250 square miles. The rainfall records at one point in the basin are available for a period of 20 years, and show an average precipitation of 18.8 inches. The precipitation on the higher portions of the drainage basin is probably much larger.

3. Gaugings of the discharge of the Shoshone River have been made at different periods and at different places, but the only continuous series of readings was made at Cody during the years 1903 to 1909, inclusive, and the results are shown in the following table:

Discharge.

	Acre-feet.
1903	975,100
1904	1,305,100
1905	977,500
1906	1,064,700
1907	1,596,500
1908	1,202,600
1909	1,413,300
Average	1,219,000

4. An examination of the hydrographs shows the following average percentage of discharge during each month of the year:

	Per cent.		Per cent.
January	2	July	27
February	1	August	9
March	2	September	4
April	4	October	3
May	15	November	2
June	29	December	2

5. It will be noted from the above that the period of maximum discharge closely coincides with the period of maximum use, so that the storage provided makes available for irrigation purposes practically the entire discharge of the river, except during the periods of abnormally high run-off.

6. Experience during the past three years indicates that an average of 2 acre-feet per acre per annum at the farm will be sufficient and probably more than is necessary for the best results. Allowing a loss of 33 per cent for seepage and evaporation in canals and reservoirs, a gross quantity of 3 acre-feet per annum will be required. The project contemplates the irrigation of approximately 164,000 acres, consequently 492,000 acre-feet, as measured in the reservoir, will be required.

7. *Prior rights.*—The State engineer of Wyoming, under date of October 1, 1910, prepared a statement showing all appropriations of water, ditches, and enlargements from the Shoshone River, and from this statement the following table has been prepared:

Appropriations.	Above reservoir.		Below reservoir.		Total area appropriated for which water must be supplied.
	Completed.	Time.	Completed.	Time.	
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
1. To May 22, 1899	2,192	.....	24,711	.....	24,711
2. Permit 2111, Cody & Salisbury, U. S. Reclamation Service	.....	.....	.....	65,803	65,803
3. From May 22, 1899, to Mar. 5, 1904	1,746	125,789	15,909	13,112	154,810
4. Reservoir permit No. 492, res. Mar. 5, 1904	.....	[1] 159,500	.....	.....	.....
5. Permit No. 1189, enl. Mar. 29, 1904	.....	.....	.....	30,745	30.745
6. Permit No. 1191, enl	.....	.....	.....	8,159	8,159
7. From May 2, 1904, to Sept. 7, 1905	80	303	103	.....	406
8. Permit No. 751, enl	.....	[1] 456,570	.....	.....	[2] 59,415
Total	4,018	126,029	40,723	117,819	344,049

[1] Acre-feet.

[2] Filings of U. S. Reclamation Service secondary permit No. 10138 and supplemental permits under No. 492 resolution and No. 751, res. enl. Irrigates 59,415 additional acres, making approximately a total of 164,000 acres to be irrigated by the U. S. Reclamation Service.

8. The first item represents filings which antedate all rights of the United States; second, a filing acquired by the United States; third, filings between the date of the Cody-Salisbury filing and the first reservoir permit; fourth, fifth, and eighth represent permits for the storage of water and for enlargements from time to time, while the sixth represents a filing acquired from the Willwood Irrigation Co.

9. From this table it appears that the full development of the project to a total of 164,000 acres can only be made if water in sufficient quantity is assured for 344,000 acres, though a large percentage of private prior rights can not be fully availed of without resort to storage either in conjunction with the United States or separately. Even assuming all prior rights to be perfected, it is found that there will be a sufficient supply of water for the project. Three hundred and forty-four thousand acres at 3 acre-feet per acre aggregate 1,032,000 acre-feet. This is only 57,000 acre-feet more than the minimum discharge of the river during the last seven years, and can readily be cared for by carrying over this, or even a greater amount, in years of maximum discharge.

10. This statement, also, takes no account of waste water or return seepage. Out of 164,000 acres of irrigable land on the Shoshone project, 100,000 acres will drain toward the Shoshone River and discharge into it above where the several canals take out, so that this return water will be available for use. The amount of this return water is indefinite, but it is believed that it will be sufficient to insure against a shortage should the run-off in future be less than that heretofore measured.

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